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ILLUMINATING ENGINEERING

Journal of the
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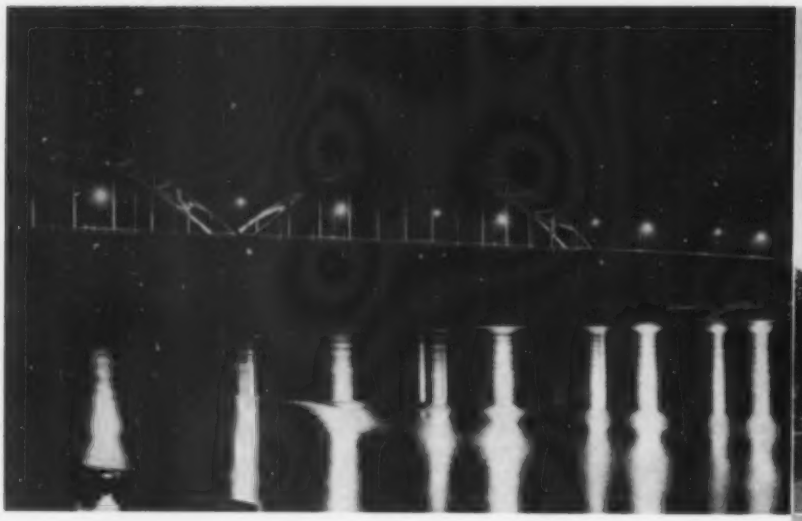

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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

March 1960

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Offices — Litecontrol #3348RS-PG 4-lamp tandem troffers with plastic grid louvers, 45° x 45° shielding.
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Lighting Progress in 1959

Prepared by the Committee on Progress of the Illuminating Engineering Society

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San Francisco was a particularly appropriate setting for the 1959 Progress Report. The theme "Trek to the West" signified the continuing journey toward the "land of opportunity" or in the case of lighting, toward "optimum seeing." The year 1958-1959 contributed more than its share of outstanding developments in this ever-changing, ever-growing and ever-better lighting industry of ours. 1959 was truly a year of accomplishment. The new higher levels of illumination were very well accepted by users in the factories, stores, offices, schools and homes across the nation. We need, however, more effort toward better understanding of the need for and practicality of the new recommendations.

New Materials and Luminaires

Equipment manufacturers have utilized many new materials combined with new ideas to create an array of fresh and attractive lighting units, as shown in the illustrations on the following two pages—Figs. 1 to 16.

Applications

The application fields were all very active during the year. The emphasis was toward markedly higher lighting levels and the use of extra-high-output fluorescent lamps, yet the environmental aspects of lighting were being improved at the same time. Many installations met or exceeded the new IES recommendations. Progress was generally in the wider use of known techniques rather than in new techniques. Applications covering public buildings, offices, stores, indoor sports areas and industrial lighting are illustrated on pages 118 through 124, Figs. 17 to 42.

Residential

Several phases of residential lighting received attention during the year. New lighting equipment incorporating unique design concepts as well as greater acceptance of higher levels were features of many installations. (See Figs. 43 to 50.)

Outdoor

Outdoor installations in 1959 were notable for the increasing use of fluorescent lamps, particularly extra-high-output lamps, and by the use of markedly higher lighting levels. Several new luminaire types are available for some of the more unusual conditions. Figs. 51 to 72 illustrate some of these.

Foreign

Lighting developments abroad were as spectacular as those at home. One significant trend was the widespread use of improved-color fluorescent lamps along with substantially higher lighting levels. "Colour" was so important in lighting installations abroad that in some cases the improved-color fluorescent lighting was supplemented by incandescent lighting. Foreign developments were certainly out-

(*Continued on page* 143)

Approved by the Council of the Illuminating Engineering Society, February, 1960. A Transaction of the IES.

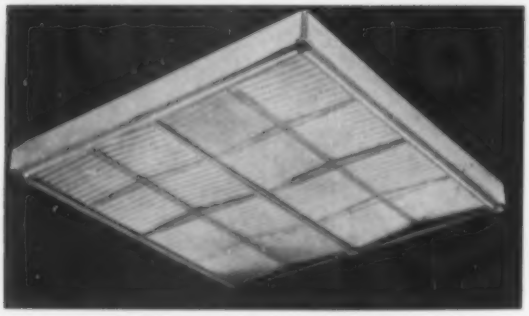


Figure 1. Lighting unit designed for flush mounting. Diffusing plastic sides put light on the ceiling for reduced brightness differences.

Figure 2. A familiar unit modernized by the use of curved wedge-shaped extruded aluminum louvers for light control and lower lengthwise brightness.

Figure 3. Low-cost, dust-proof luminaire designed for the food handling industry.

New Materials and Luminaires

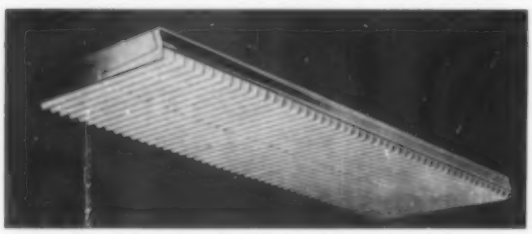


Figure 4. One of the first commercial lighting units designed for extra-high-output lamps. The unit is well-shielded for comfortable brightness.

Figure 5. A unit designed to help reduce glare. Recessed configurated plastic is partially shielded by side panels and center "V."

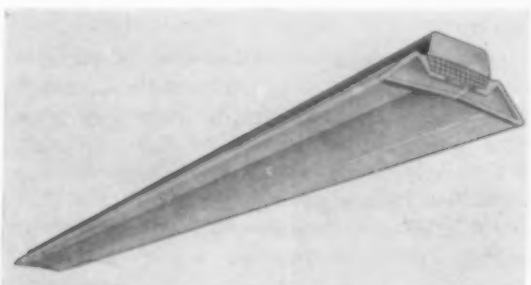


Figure 6. "Swept wing" design with plastic "wings" for soft uplight and low side brightness. Bottom section is either plastic or metal louvers.

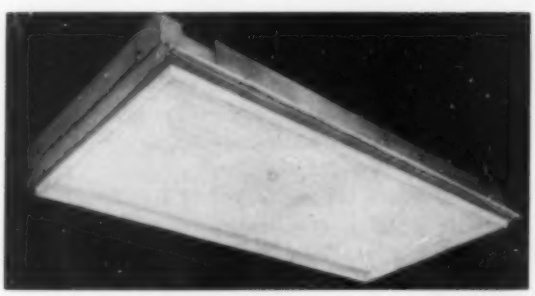


Figure 7. Recessed luminaire with prismatic control. Lighted edge of the lens extends down far enough to throw some light up onto the ceiling.

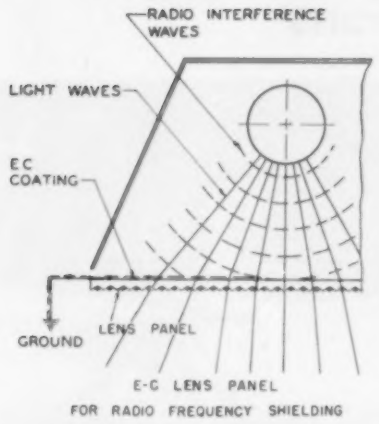
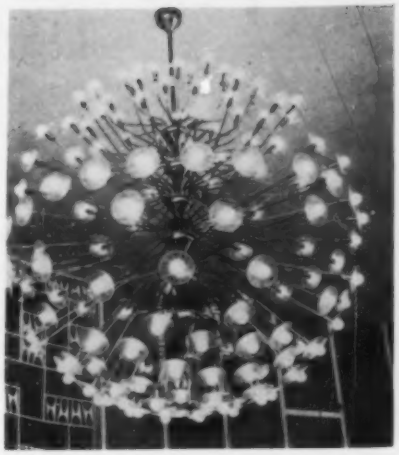


Figure 8 (left). Glassware for fluorescent units is treated with an electrically conductive coating for the elimination of radio interference.

Figure 9 (right). A truly unique creation in the lobby of an Atlanta, Georgia motel. The result of the 1957 IES National Technical Conference?



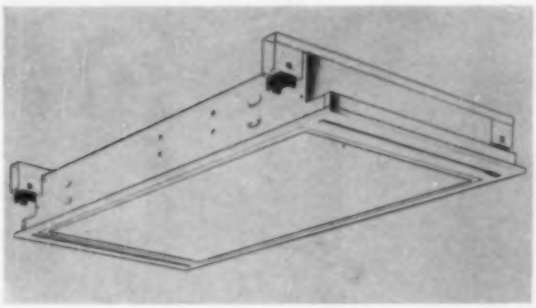


Figure 10. New combination lighting and air diffusing unit for Crown-Zellerbach Building in San Francisco.

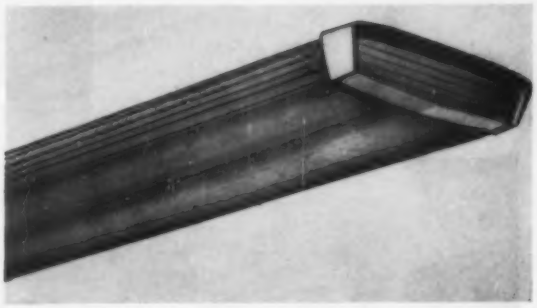


Figure 11. New styling concept in the contemporary manner—plastic ends.

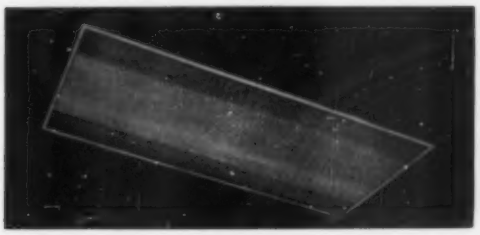


Figure 12. Sagless panels in sizes up to two- by four-feet are produced by extruding and embossing process.

Figure 13. Colorful desk lamps incorporating modern design with adequate fluorescent illumination.

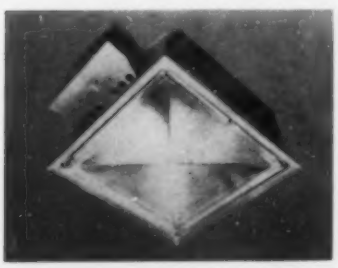


Figure 14. Unit with unique "bi-focal" prisms for uniform brightness and concealed lens mount. Small corner clips allow lens to be lighted to edge of door opening.

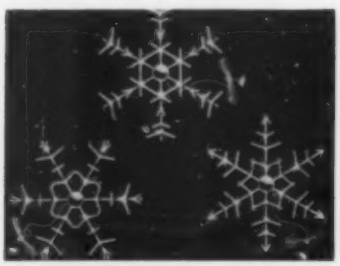


Figure 15. This unusual snowflake design uses a silvered-bowl lamp to provide shimmering starlight effects for outdoor decorative uses. These can also be used indoors.

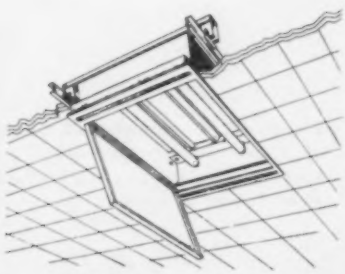


Figure 16. This unit incorporates a spring-loaded door frame to compensate for the irregular ceiling openings which are often found in recessed troffer installations.

Lighting Applications

Public Buildings

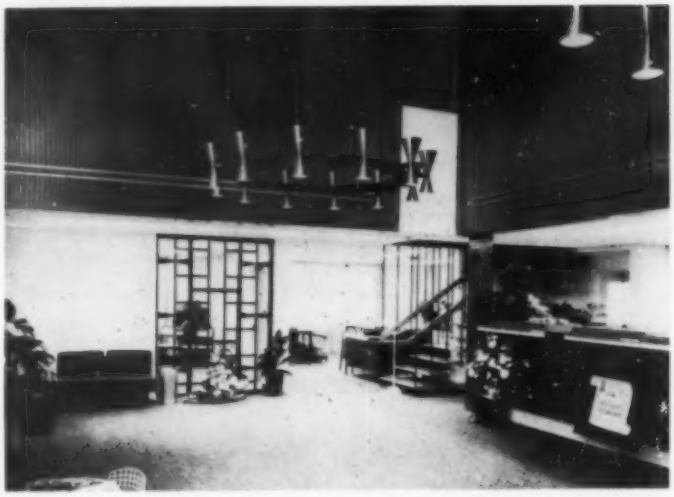


Figure 17. Bank lobby with decorative luminaire as center of visual interest. Troffers are used in work areas.

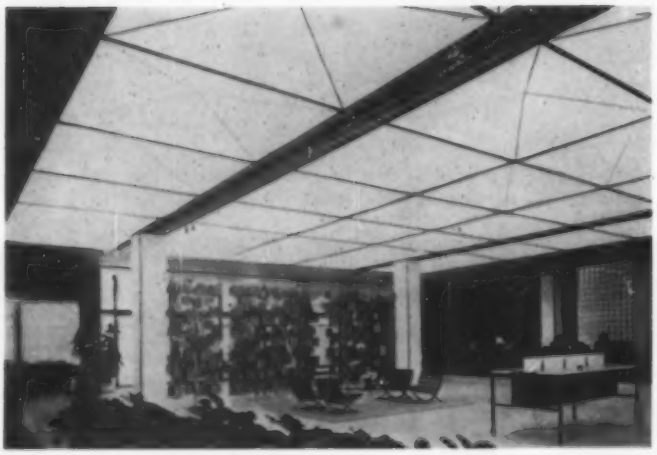


Figure 18. This pleasant lobby in an eastern bank is provided with 100 footcandles in a pleasing and cheerful environment. Lighting diffusers are plastic, in pyramid-shaped panels, 7 by 9 feet in size—the largest single pieces of formed lighting elements yet, and still rugged and light in weight.

Figure 19. A western bank uses louvers of a new construction—metal cylinders spot welded together. Rugged and unusual in appearance.

Offices

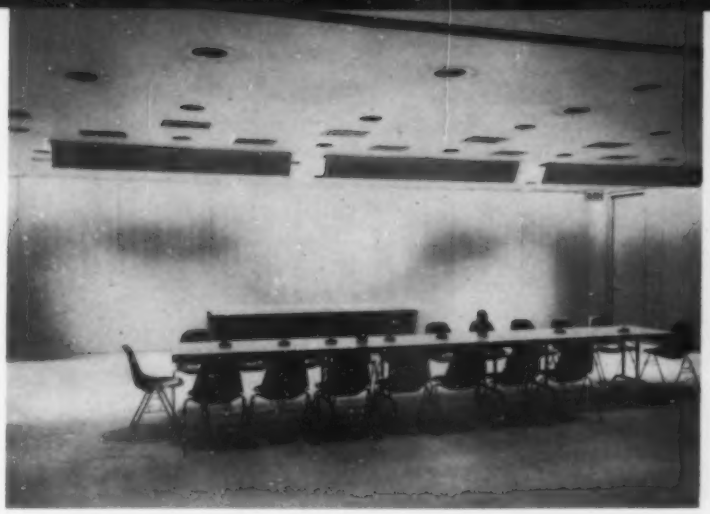
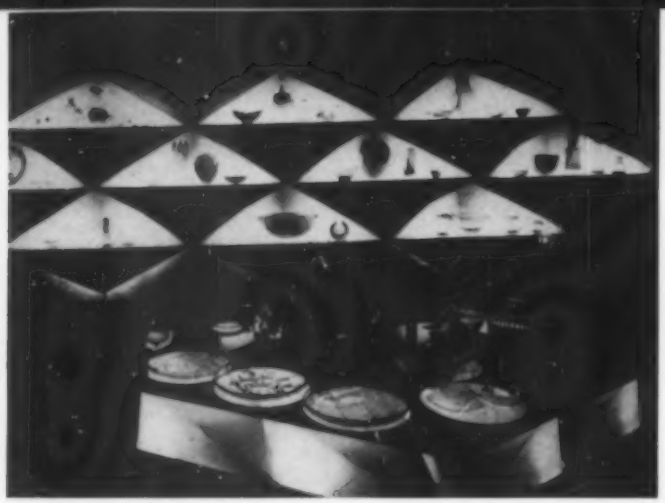


Figure 20. Conference room tailored to the visual needs of the conferees employs two dimmer-controlled lighting systems. The general system is augmented by three large retractable multiple PAR38 incandescent flood units to wash the display wall for easy appraisal.

Figure 21. Different treatment of a floating panel luminaire. Spill light filtering through the pattern of holes around the periphery adds a distinctive touch.

Figure 22. New concept of "floating panels" provides good appearance, comfort and low cost installation for this drafting room.

Figure 23. An unusual luminaire pattern with standard modular elements provides 150 footcandles on the modern light-colored desk.



Stores

Figure 24. Dramatic formed plastic luminous panel adds life and color to this display of fine china and glass. Lighted triangle-shaped niches are recessed in the plastic, so formed that the bottom surface of the niche serves as a shelf. Even table display has luminous circles for each plate.

Figure 25. Decorative unit in jewelry store is complemented by functional downlights supplying glamor and glitter needed for display of fine gems.

Figure 26. Lighting equipment display room achieves order out of chaos by showing only a few well-selected luminaires rather than crowding in as many as there is room to hang.

Figure 27. Supermarket with 300 footcandles. Recessed downlights and well-shielded extra-high-output fluorescent lamps are integrated into a pleasant architectural design.

Figure 28. Unusual indirect lighting system using massive element down the center of the store to house six rows of extra-high-output fluorescent lamps. Downlights add sparkle and emphasis.

Figure 29. Combination of incandescent and fluorescent lighting provides 300 footcandles for high-speed merchandising in this supermarket.

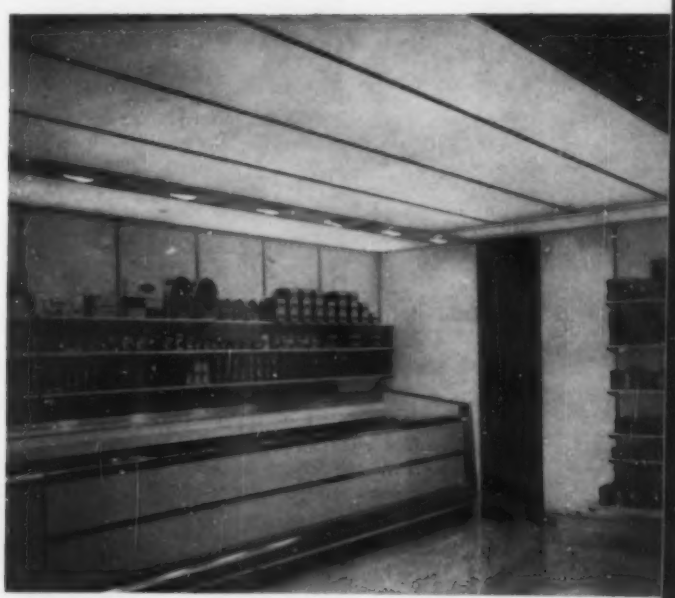


Figure 30. Store lighting laboratory capable of showing from 0 to 400 footcandles. Here the effects of various lighting systems can be evaluated.

Indoor Sports Areas

Figure 31. This indoor jai alai court has 100 footcandles supplied from extra-high-output fluorescent units.

Figure 32. Extra-high-output fluorescent lighting of 100 fc makes this gymnasium fun for players and spectators alike.

Figure 33. "Natatorium" uses extra-high-output fluorescent luminaires in an up and down cove to supply 200 footcandles on the apron and 50 footcandles on the pool.

Industry

Figure 34. The seeing task here is difficult and requires magnification for easy seeing. Lighting is 200 footcandles general plus 400 supplementary, for a total of 600 fc on the work.

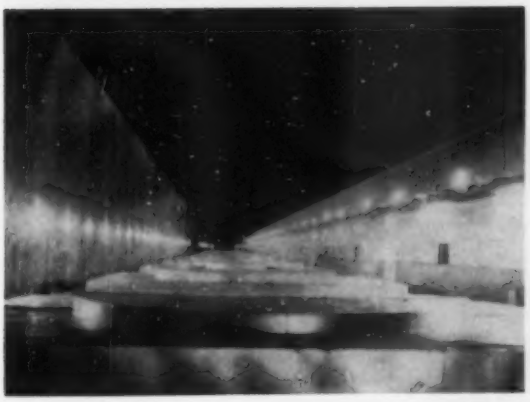


Figure 35. The new St. Lawrence Seaway project includes several large power stations. Here is a nighttime view of one of these power stations which has been floodlighted with mercury units.

Figure 36. Interesting wall installation of fluorescent diffusing panels supplies vertical illumination in one of the turbine rooms for good visibility during installation of machines.

Figure 37. This dramatic "before and after sequence" illustrates the tremendous improvement in visual environment so typical of the whole gamut of industrial applications—from a gloomy 15 footcandles above, to a comfortable 100-150 footcandles at right, with extra-high-output fluorescent lamps. Even small plants are using better lighting for more profitable operation.

Figure 38. Electrical relay assembly plant with over 300-footcandle lighting level. Aluminum reflectors help reduce luminaire brightness and assure comfort.

Figure 39. Rough machine shop meets IES recommendations for this type of work. Comfort is achieved with 25 per cent uplight and 35-degree shielding.

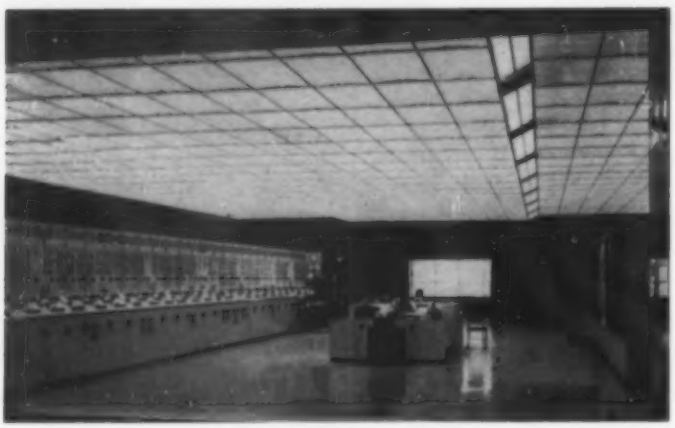


Figure 40. Prismatic lens luminous ceiling provides 150 footcandles of general lighting in control room. Lighting on boards is augmented by a continuous row of two-lamp asymmetric units.

Figure 41. This welder has more light on his work than could be supplied by full sunshine. A level of 10,000-15,000 footcandles from three 500-watt PAR64 spot lamps gives the welder good visibility through his mask, even when striking the arc.

Figure 42. Here is a large installation of reflectorized lamps. 300-watt PAR56 lamps provide 500 footcandles along the full 30-foot length of the steel billet which is being surface-ground. Small flaws are easy to see with this lighting system.

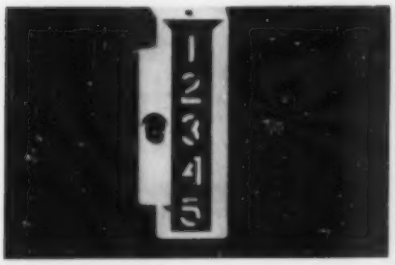


Figure 43 (above). Lighted house-number doorbell operates from bell transformer. Small high-brightness incandescent lamp takes negligible power but ensures proper home identification.

Figure 44 (right). Car port converted to screened living-garden area. Flexible lighting is key to creating pleasant moods.

Residential Lighting

Figure 45. Inconspicuous built-in lighting provides good visibility for reading sheet music. Drawing below shows principle of edge lighting through clear plastic. The 15-watt T8 fluorescent lamp provides 25 footcandles on sheet music.

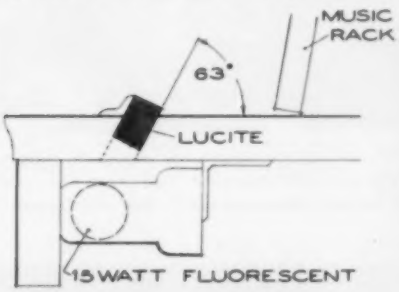


Figure 46. The luminous free-standing screen in the background makes an interesting room divider.

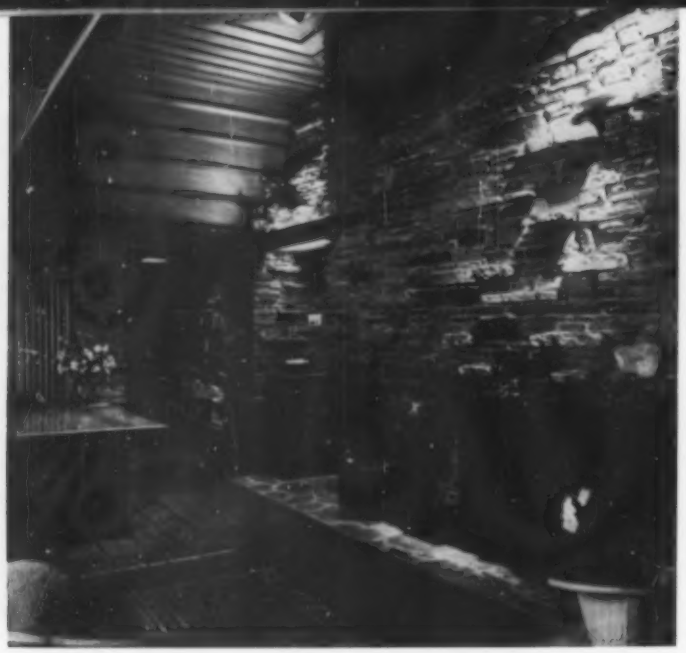


Figure 47. The textural quality of the stone in this fireplace wall is enhanced by grazing light from a 150-watt PAR spot. A 300-watt reflector flood lights the dining area. The lighted valance in the background supplies work light for desk as well as decorative lighting for stone in upper wall.

Figure 48. Luminous ceiling elements supply shadowless light for wall desk. Decorative pull-down unit over main desk provides center of interest as well as adequate illumination.

Figure 49. Converted attic owes its charm largely to well-integrated lighting. The end-wall valance flows smoothly into side cornice.

Figure 50. This home in the "modern manner" uses a lighted valance as a structural element of the architectural design. Six 40-watt rapid-start Homeline lamps on dimmer supply reading light or lower level for conversation.

Outdoor Lighting

Figure 51. Night view of the longest continuously lighted roadway in the world. 3250 mercury and 1000 fluorescent units are used to light the 53 western miles of the Connecticut Turnpike.

Figure 52. Mercury is used here for floodlighting a work area in a steel mill. This technique is also becoming more popular in railroad yards.

Figure 53. High school football field, one of several reported installations of 1000-watt mercury lamps on 1500-watt ballasts, has 20 fc from over-wattaged lamps.

Figure 54. This service station is typical of many modern installations. Extra-high-output fluorescent units provide 100 footcandles under the canopy and substantially higher levels than are usual throughout the surrounding area.

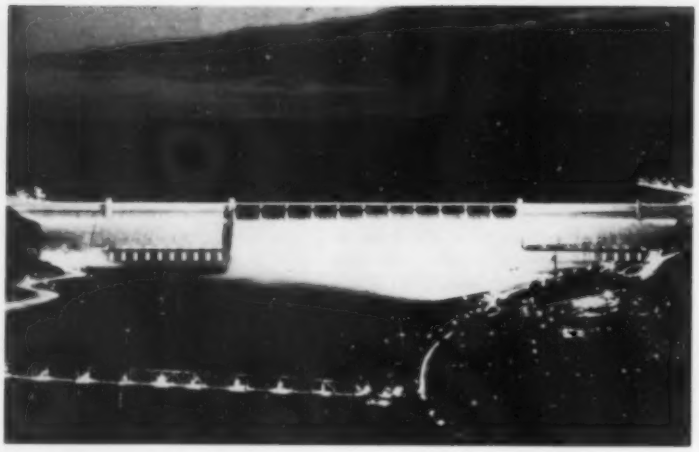


Figure 55. Unique multi-colored floodlighting system is used at Grand Coulee Dam. The color changes every 12½ seconds for a 30-minute spectacular display. The spill-way is twice as high as Niagara Falls and has a surface area of 16½ acres.

Figure 56. Poster panel at right is a luminous panel lighted to 300 foot-lamberts. Compare it to one of the best conventional panels at left.

Figure 57. (below). Chicago's Museum of Science and Industry uses a continuous row of extra-high-output fluorescent units in a cornice to flood the front of the building. 700-watt filament-ballasted mercury lamps floodlight the dome.

Figure 58 (right). Mercantile Bank in Dallas has a shimmering tower with one hundred and forty-four 500-watt PAR64 spots aimed horizontally. From any direction, a flashing sequence of three stars in three different patterns is visible.

Figure 59. Luminous store front is composed of plastic panels lighted with rows of extra-high-output fluorescent lamps to a brightness of 750 fL.

Figure 60. This interesting store front features a combination mercury-incandescent floodlighting system and a lighted silhouette sign.

Figure 61. Incandescent downlights, sign tubing and fluorescent luminous letters are used on this store front to create a real "shopper stopper."

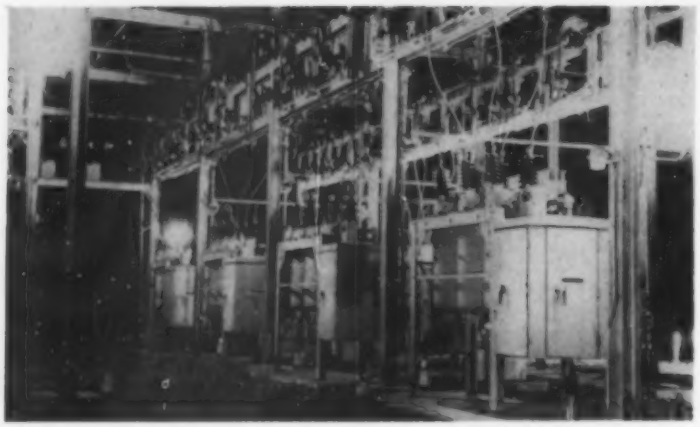


Figure 62. This is reported to be the first outdoor switchyard floodlighted with mercury luminaires.

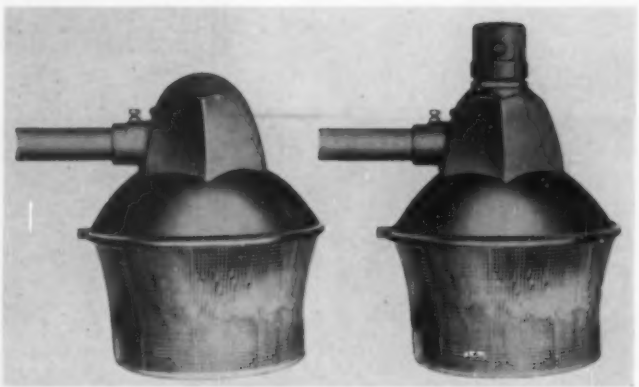


Figure 63 (left). New prismatic unit provides three-way distribution pattern for mounting at "T" intersections.

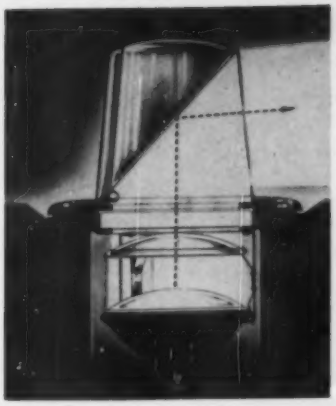
Figure 64 (above). Open bottom prismatic units are being used in rural outdoor work areas, roadside markets and similar areas.

Figure 65 (far left). Modern post top luminaires have improved appearance for parking area and entrance applications.

Figure 66 (left). Post lanterns have become popular in many areas. This typical unit incorporates a convenience receptacle as well as a photocell control.

Figure 67. Marine navigation light provides positive guidance by using a specially designed prismatic plastic lens. This is the largest plastic lens yet, approximately 18 inches high.

Figure 68 (far right). The U.S. Air Force is testing this recessed unidirectional airport marker light. The unit's unique feature is the expendable plastic optical system which extends about eight inches above ground.



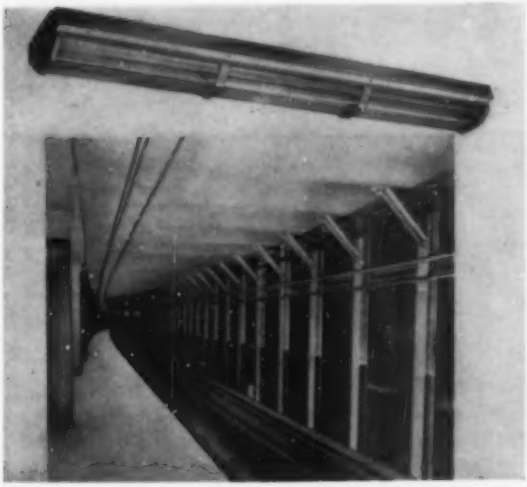


Figure 69. Waterproof luminaire featuring prismatic lens and extruded aluminum channel. It is designed for subways, airport ramps, tunnels and underpasses.

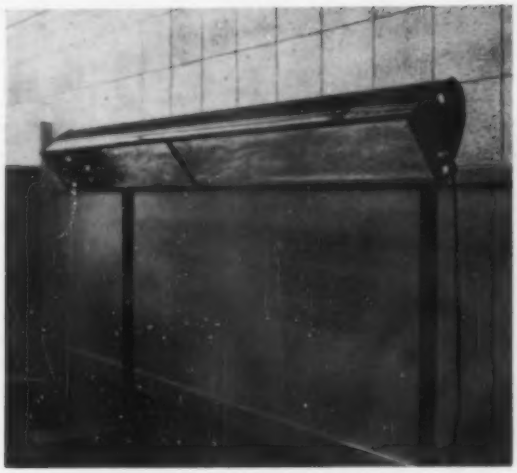


Figure 70. Unit with specular reflector and clear cover designed specifically for Panama Canal to light the banks for glareless guidance of passing ships.

Figure 71. Explosion proof unit for use wih PAR64 projector lamps.

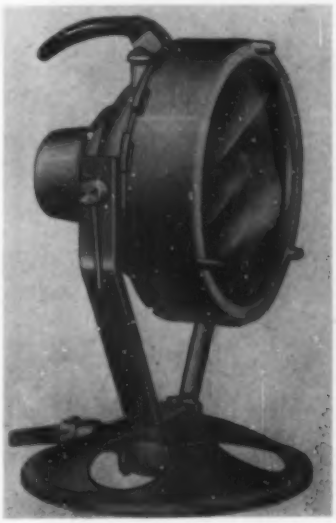
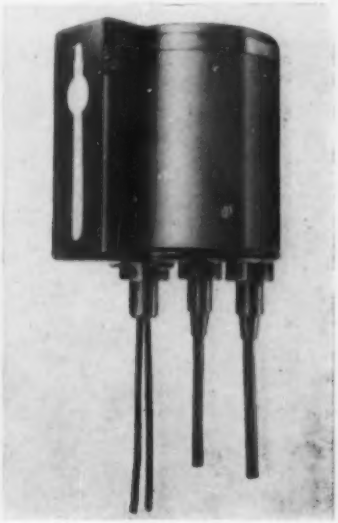


Figure 72 (far right). New outdoor mercury ballasts are much lighter in weight than previously. This two-lamp 400-watt ballast is 16 pounds lighter than previous models.



Lighting Progress Abroad

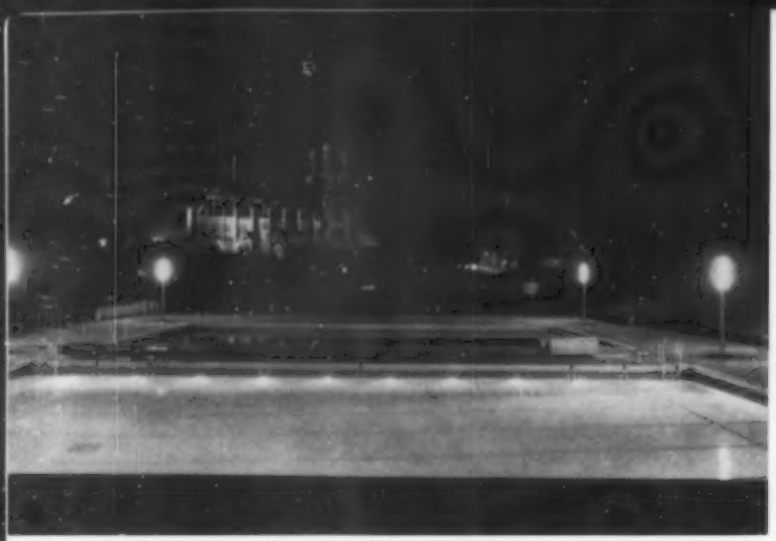


Figure 73. French installation featuring swimming pool floodlighted with 500-watt incandescent lamps. Floodlighted Notre Dame Cathedral in background completes the picture.

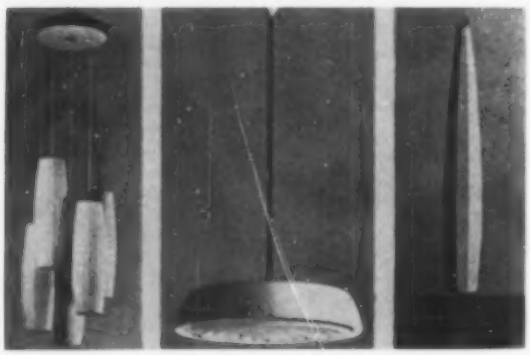


Figure 74. These decorative commercial lighting units are typical of the new styling of fluorescent luminaires found in Germany in the past year. Both circline and straight fluorescent lamps are used.

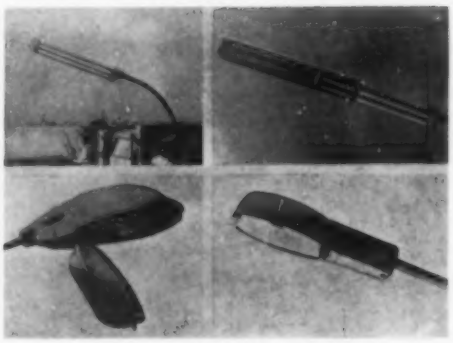


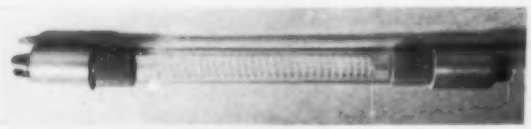
Figure 75. Top: Unique slide-on plastic cover for a French fluorescent street lighting unit. Bottom: Italian prismatic refractor for 400-watt mercury lamps with an integral ballast.

Figure 76. Outdoor fluorescent floodlights used in a German railroad classification yard.

Figure 77. British IES celebrated its Golden Jubilee in 1959. Symbol of event was this giant hand holding "Sunburst" luminaire.

Figure 78. Gymnasium lighting in this Netherlands installation is from a combination reflector incandescent and improved-color fluorescent system supplying 50 footcandles.

Figure 79 (above). This unit has its aluminum reflector mounted on bearings and is rotated once per hour by a small motor. Lighting changes in amount and direction, giving a feeling similar to changing light outdoors.



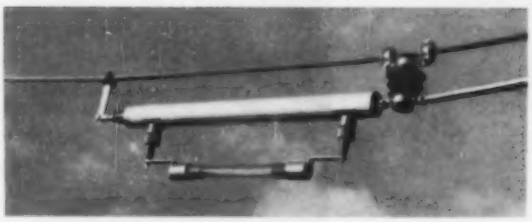


Figure 80 (right). Neon warning lamp designed for use on transmission lines up to 380,000 volts. It is used near airports to alert low-flying pilots to the presence of high-voltage lines.

Figure 81. Lighting in this West German tunnel entrance is by multiple rows of 65-watt fluorescent lamps supplemented by thirty 400-watt and twelve 250-watt mercury lamps. Several hundred footcandles are provided for daytime entrance, with progressive reduction as eyes become adapted.

Figure 82. DeAddington's office in London is typical of improved office practice abroad. A 120-footcandle level is provided on the desk from the interesting combination incandescent-fluorescent lighting system.

Figure 83. This garage, carved out of solid rock for safety in an emergency, has 50 footcandles of light from 40-watt enclosed plastic units.

Figure 84. The single xenon arc lamp in the center of this 92,000-square foot auditorium in Berlin supplies two million lumens or over 10 footcandles. The quartz lamp is two inches in diameter and has good color quality.

Figure 85. Scandinavian supermarket is provided with a level of 175 footcandles from modular units incorporating six 40-watt fluorescent lamps. The contrasting ceiling pattern and incandescent downlights combine for a dramatic effect.

Figure 86. Twenty-four two-lamp improved-color cool white fluorescent units provide 50 footcandles in this French classroom.

Figure 87. Interesting architectural treatment is the feature of this gift shop in Holland. General lighting from fluorescent luminaires is 70 footcandles. Over 200 footcandles are provided in the areas highlighted by the 150-watt reflector lamps.

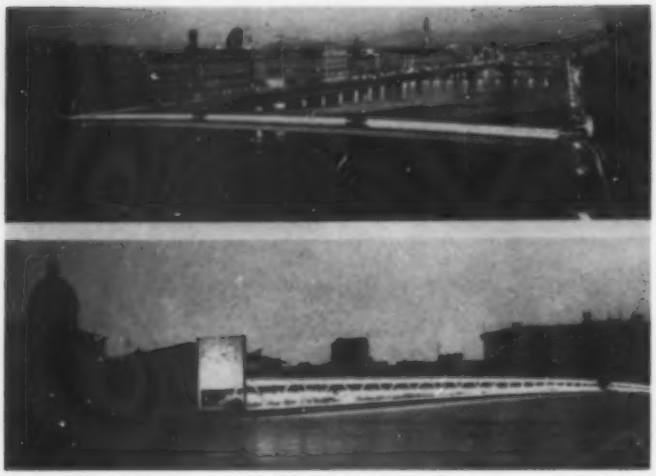


Figure 88. In Florence, Italy, the Amerigo Vespucci Bridge features this unusual inverted trough fluorescent street lighting. Lower view is a low-level close-up of the bridge; upper view is from the air.

Figure 89. Another Italian development is this flexible floodlighting unit. Internal reflectors are adjustable to provide various sizes and shapes of beam.

Figure 90 (far right). Sweden produced a completely waterproof fluorescent lamp ballast. The device has a low noise level due to melted plastic impregnation.

Figure 91. Ornamental standards in parking and loading area of a Berlin terminal. Twenty-four 20-watt fluorescent lamps are used in the flat top of each standard with eight 65-watt lamps in the vertical section.

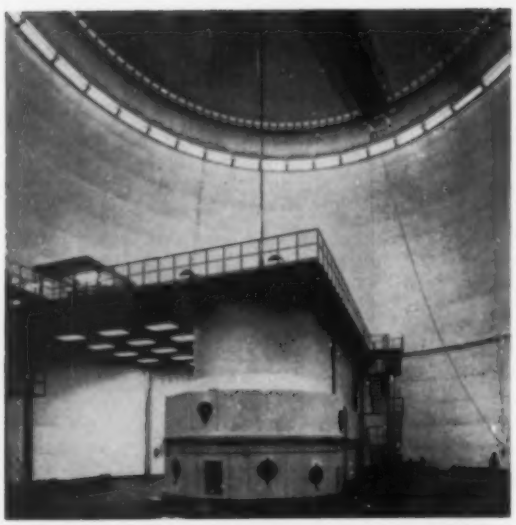


Figure 92. Unusual architecture of egg-shaped windowless atomic reactor room in Munich is enhanced by double ring of fluorescent luminaires. One row lights the dome; the other the rest of the room. Additional recessed fluorescent units are used under the platform.

Specialized Equipment and Applications

Figure 93. The modern hospital is being markedly improved in environment and lighting. This installation of individual valance lights with tippable shields for control of up and down light is typical.

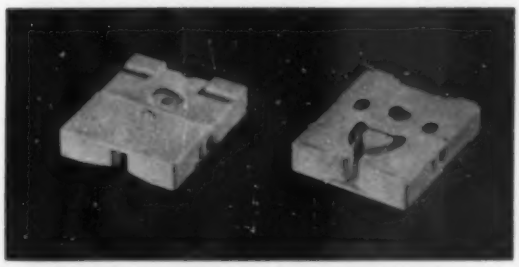
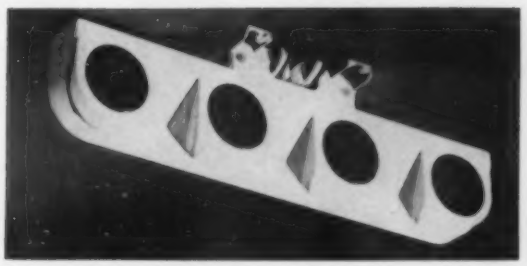


Figure 94. The lampholder industry has introduced these new types of all plastic units. The thinner section of the butt-on type makes it possible to make luminaires of four-foot dimensions for continuous runs with metal ends behind the sockets. The all plastic turret type is available in two- three- and four-lamp designs.



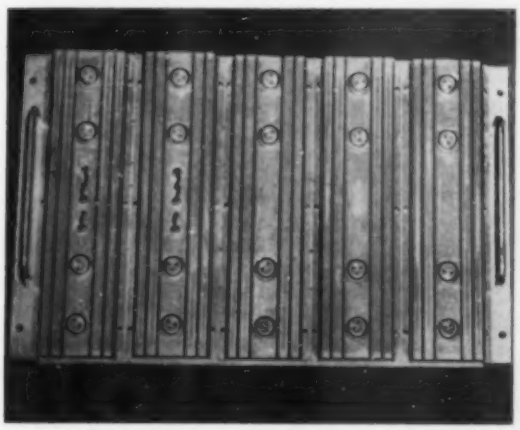


Figure 95. The first commercial installation of 1500-cycle static high frequency is at the Cleveland Engineering Society. This illustration shows the converter prior to its installation.

Figure 96. This unit was designed to minimize vandalism. The plastic bowl will stand up under thrown rocks and even B-B pellets. Several other units of the prismatic type are also available for this type of hazard.

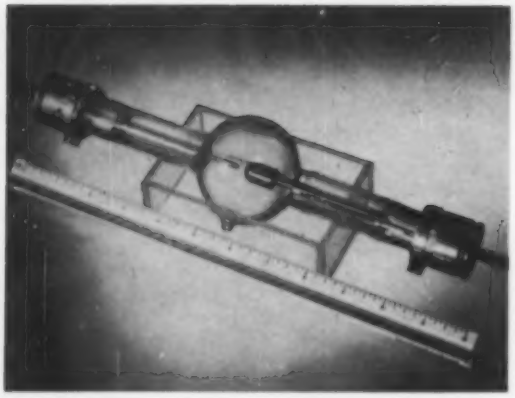


Figure 97. This new two-kilowatt compact xenon arc lamp is operated directly from 28 volts d-c. The arc is only four millimeters long and about two millimeters wide. Its maximum brightness is about 2500 candelas per square millimeter which provides 50 million candlepower from an 18-inch searchlight.

Figure 98. The large unit shown here was built by the National Bureau of Standards for the Navy Bureau of Aeronautics to determine the optimum candlepower for anti-collision use on aircraft. The 2000-watt rotating beam unit produces 12,500 candlepower of red light. Flight tests indicated too much atmospheric back-scattering, so the final version is the smaller one on the right, with about 4000 candlepower of red light.

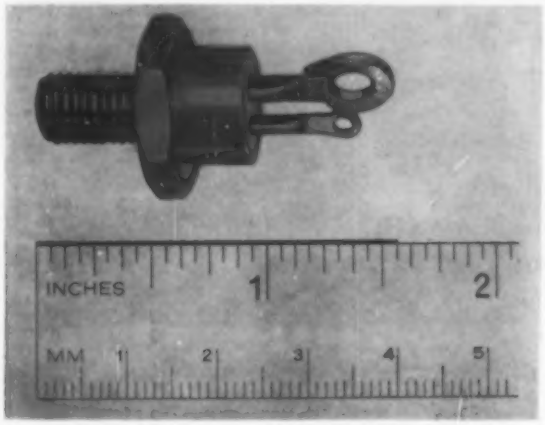
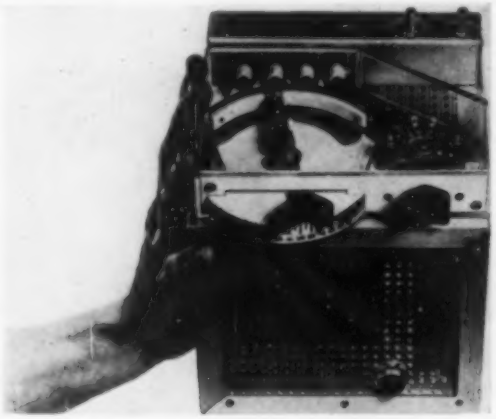


Figure 99. Markedly improved theatrical dimmers became available this year with the development of high current silicon controlled rectifiers. Pictured at right is a four-kilowatt unit weighing only five pounds.



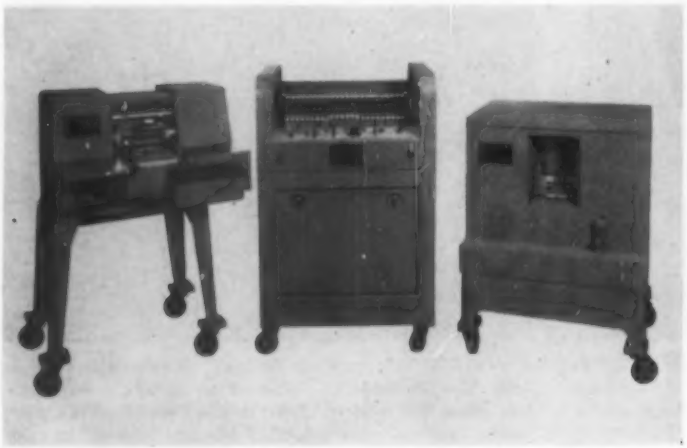


Figure 100. This fully automatic infinite preset dimmer control system allows complete programming of all lighting effects. Each scene is recorded on a punch card. One lever fades at any desired speed from one card to the next. Cards can be skipped or over-ridden by manual control. When over-ridden, a new card can be made so that the revised settings can be used later. The board can also be used manually in a normal manner.

Light Sources

Figure 101 (left and above). Several new bulb shapes have been made available this year so residential or commercial user can choose the shape most pleasing to him. Lamps in photo at left have been designed for residential application without a fixture. These new shaped bulbs generally have longer (2500 hours) life.

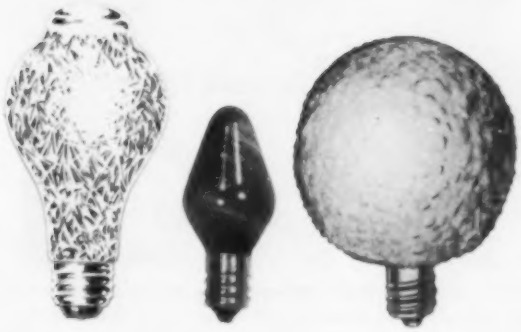


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Figure 102 (left). Several new finishes are also available for decorative use. (a) Chandelier or candelabra lamp, (b) Christmas lamp for glamor and variety. (c) Christmas lamps with outer coating of white plastic give unlighted appearance of tree full of snowballs. When the lamps are lighted, however, they change to their respective colors.

Figure 103. Nighttime photo of the Great Pyramid and the Sphinx, complete with Arabs, camels and tents, illustrates the spectacular potential use of massed photoflash lamps. Sixty-five hundred lamps and 14 miles of wire were used in this photo of the last of the Seven Wonders of the World.

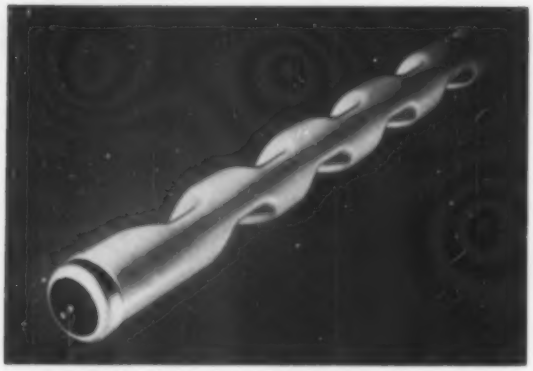

Figure 104. New fluorescent bulb shape has been introduced to produce a longer arc length for greater light output without changing installation dimensions or socket spacing. Improved output and maintenance of extra-high-output lamps have emphasized their usefulness, particularly in high footcandle applications.

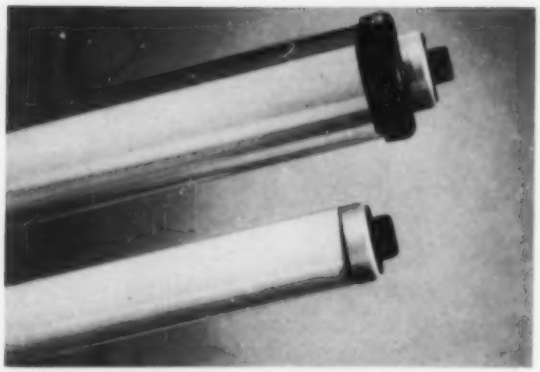

Figure 105. Fluorescent lamps for outdoor lighting are growing in popularity. In addition to the extra-high-output lamps which are now being used, some new dimension tubes have been introduced. Jacketing a fluorescent tube helps overcome the light losses due to low temperatures, a problem in outdoor lighting.

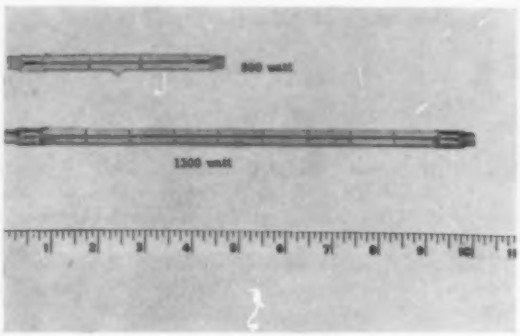

Figure 106. Unique in the incandescent field is this pencil-thin tubular quartz lamp. The 500-watt 4½-inch lamp produces 10,500 lumens, while the 1500-watt 10-inch lamp has a 33,000-lumen rating. The quartz lamps have a 2000-hour life and do not darken visually during life. The secret is the regenerative iodine

cycle which actually returns evaporated tungsten particles to the filament rather than letting them accumulate on the tube walls. The effectiveness of this "cleaning" action is shown in the illustration above. This very small linear light source makes possible extremely well-controlled beams, when used with specular reflectors.

Figure 107. Incandescent telephone switchboard lamps have been increased 60 per cent in candlepower by using flat ends on the bulb and by moving the filament closer to the end of the bulb.

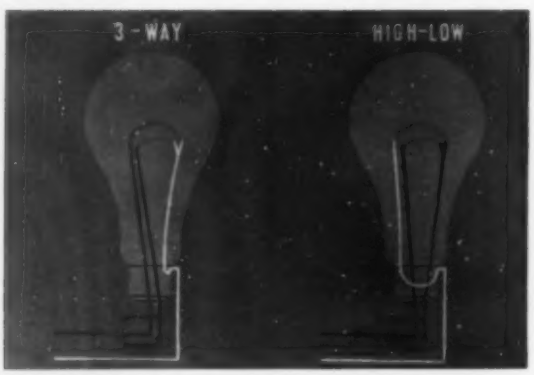

Figure 108. Simple change in base of familiar "three-way" lamp has produced a "high-low" two-lighting-level lamp. For high position, single wattage high efficiency filament is used; for low level, two filaments are used in series. Lower wattage filament seldom burns out so problem of "half burnouts" is virtually eliminated.

Figure 109. An automotive manufacturer is using electroluminescence in some 1960 models (above). The electroluminescent lamp is also being used in red for aircraft instrument panels. On a much larger scale (left) electroluminescence is used in highway signs (three-foot letters) on new high speed thruways.

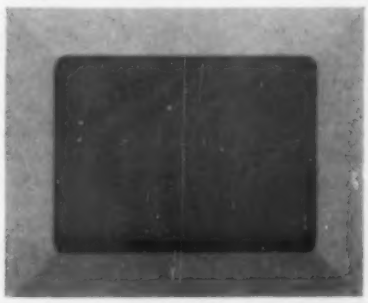

Figure 110. These night lights are examples of the use of neon high brightness glow lamps (at left) and electroluminescence (at right) for providing low level lighting for moving around the home at night.

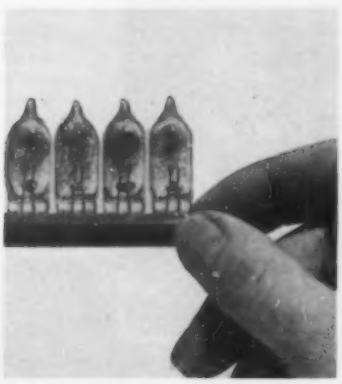

Figure 111 (far left). This is probably the tiniest lamp yet. It is designed for lighting the individual holes in punch cards. This incandescent lamp illustrates the advanced development in miniaturization.

Figure 112 (left). Another example of miniaturization are these baseless all glass photoflash lamps. Available in clear or blue, they have the same output as the previous M2 and M2B. Grooved base makes repeating flash guns possible.

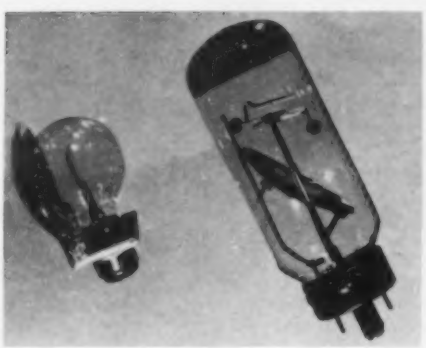

Figure 113 (right). New low cost streamlined film projectors available today depend on new designs of projection lamps. Reflectors are either built-in or built-on as shown here.

Figure 114 (far right). Built-in reflector used in the optical system of two-filament bulb for the boating industry. Similar in principle to automotive headlights, these supply safe lighting for nighttime navigation.

Education and

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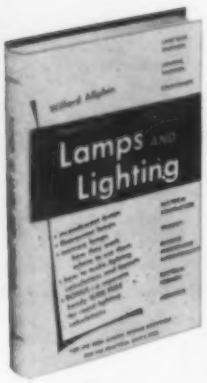

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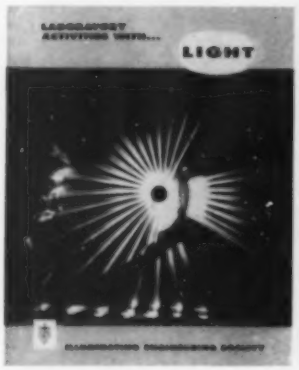

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Figure 115. (a) The long-awaited Third Edition of the *IES Lighting Handbook*, which has already sold over 10,000 copies, reflects the higher illumination values recommended as a result of the Blackwell researches. (b) *Primer of Lamps and Lighting*, keyed to the practical viewpoint, is designed as a reference text for secondary schools and guide for the non-technical lighting practitioner. (c) An IES booklet designed for school science programs, "Laboratory Activities with Light" outlines many basic experiments in light and lighting. (d) "Color in Relation to Illumination Levels" discusses factors of choosing colors for use in areas having different levels of light as well as the effects of light distribution and inter-reflections on color and light utilization.

Figure 116. Ratio-Recording Spectroradiometer plots the relative output of fluorescent lamps throughout the visible spectrum. The color point of the lamp is easily computed from these data. This development is of international significance as the International Commission on Illumination (CIE) has recommended that all international comparisons of color of fluorescent lamps be on the basis of spectroradiometric measurements by January 1, 1961.

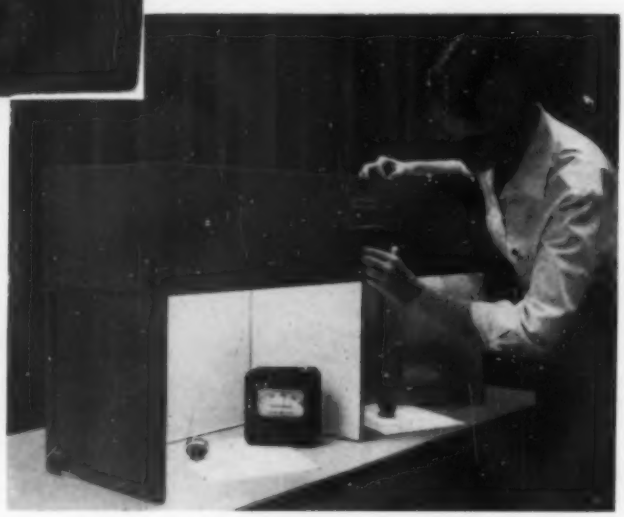


Figure 117. Here is a visual demonstration that for the first time makes it easy for the user to select the level of light desired for a particular task and compare it directly with the visibility of the same task at the lighting level at which it is being performed. Portable, this device can be used in the office, store or plant of the user.

Measurement

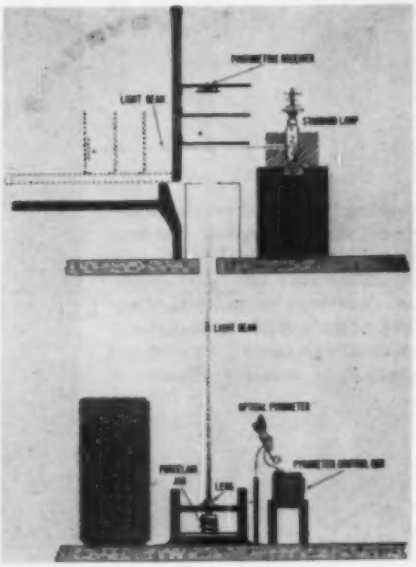


Figure 118. The National Bureau of Standards has installed, permanently, a freezing platinum primary standard of light. The blackbody consists of an ingot of pure platinum into which a sight tube is inserted (lower portion of drawing). The ingot is heated electrically by a 450-kc generator. (Photometric equipment is on upper level.) Photo shows operator raising photometer into position to receive light from Primary Standard. Repetitive tests indicate accuracy of ±.1 per cent under widely different experimental conditions.

(*Continued from page* 115)

standing during the year in equipment, sources and application. (See Figs. 73-92.)

Specialized Equipment and Application

Several ballast manufacturers introduced new single-case ballasts for extra-high-output lamps that are cooler, quieter and lighter in weight. Elimination of the requirement for two ballast cases for the eight-foot extra-high-output lamps should be welcomed by all users of such lamps. Ballasts for mercury lamps are also smaller, due to changes in lamp electrical characteristics as reported previously. Weatherproof ballasts for outdoor mercury lamp operation are many pounds lighter, in some cases as much as 30 per cent less than previous designs. Both constant wattage and simple reactor type ballasts are available for 400-watt lamps. (See Figs. 93 to 100.)

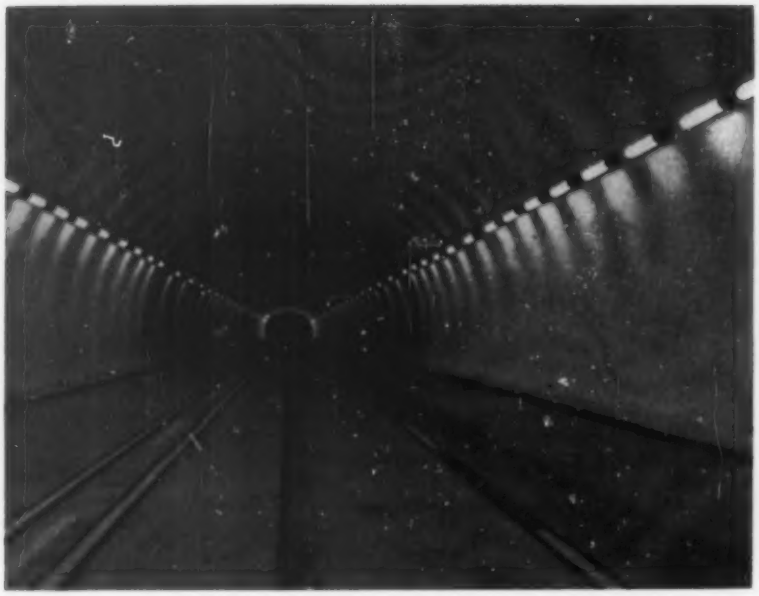
Light Sources

Nearly every year really important developments in light sources can be reported and 1959 was unusually fruitful. New shapes, new finishes, filament designs, as well as basic improvements in performance were all part of the year's accomplishments. (Figs. 101 to 114.)

Education and Measurement

In the fields of lighting education and the measurement of light, several significant developments were reported during the year. Some of these developments are shown on this page and the facing one.

Figure 119. Secondary candlepower standards are now made with inside frosted bulbs rather than the clear type. Proper alignment and candlepower variation due to filament distortion are much less of a problem.



Looking north through Mule Pass Tunnel at a point 100 feet in from south portal. This is a nighttime shot with day circuit on. Note high intensity lighting at portals (49-51 footcandles), reduced intensity (11 footcandles) in center portion.

Lighting for

THE INABILITY of the eye to adapt quickly from the several thousand footcandles of daylight to the lower levels of artificial lighting is one of the prime causes of tunnel accidents. In poorly lighted tunnels, most accidents occur in the first 500 feet, most often because the motorist is unable to discern objects in his path. To facilitate the adaptation of the eye and increase tunnel safety, lighting specifications for tunnels call for higher footcandle levels at the entrance with gradual reduction through the central portion then rising again toward the exit.

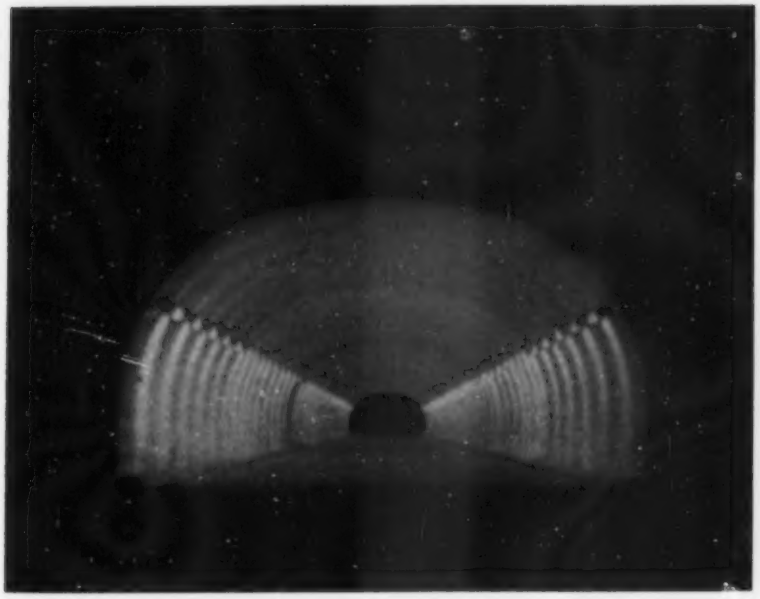
Mule Pass Tunnel on US 80, north of Bisbee, Arizona, and the road leading to it, were designed by the Arizona Highway Department in June, 1958, to replace an old, narrow, winding road with a summit elevation of 6040 feet. The tunnel is 1400 feet long, 23 feet from crown to roadway and 42 feet wide, providing for three 11-foot traffic lanes —two lanes uphill, one downhill, with curb, gutter and two-foot sidewalk on each side. The roadway was designed on a 6.5 per cent grade, with a one and one-half-foot whistle stripe the only physical barrier between traffic directions.

Cars enter the tunnel at between 35 and 45 miles per hour; traffic volume is medium, averaging 1100 cars per hour. Inside surface of the tunnel is concrete, covered with white vinyl paint which gives a reflection factor of approximately 60 per cent to the walls and ceiling. Surface of the approach roadway is black asphalt; the tunnel road surface is concrete.

Design goal for daytime lighting in the tunnel was set at 45-50 footcandles at the portal entrances with a gradual reduction to a level of 10 footcandles through the center portion. Nighttime lighting was to provide 5-7 footcandles, with transitional lighting between the approach road and the tunnel to be installed at a later date, when the Highway Department's budget permits.

Among the preliminary problems to be solved in the lighting design for Mule Pass Tunnel was that of maintenance—how to protect the fixtures from the smoke deposited by diesel trucks passing through the tunnel. Solution to this was fixture mounting below the exhaust area, 14-14½ feet above the road, approximately over the curb area. Preliminary studies of the driving habits of truckers assured the lighting engineer that fixtures mounted at this location would be safe and easy to maintain.

With the mounting location determined, the next consideration was fixture selection. To meet the



Nighttime view of Mule Pass Tunnel with night circuit energized. Note even distribution of light along tunnel walls. Measured illumination level at entrance is 2.5 footcandles; at 100 feet into tunnel, 6.6 footcandles; in center of tunnel, 5.3 footcandles.

Mule Pass Tunnel

specifications of low brightness factor, high light output, minimum glare, long lamp life and low energy consumption, a fluorescent tunnel fixture was selected. The fixtures are equipped with tube sockets for two six-foot T12 cool white high-output rapid-start lamps. Ballasting is for a multiple 110-volt, 60-cycle circuit with a minimum starting temperature of —20F, each lamp having its own ballast. Mounting brackets are provided for adequate adjustment of the light pattern at a 45-degree angle to the roadway.

For daytime operation, the first 150 feet of the tunnel were designed for 45-50 footcandles on opposite 6.5-foot average linear spacings; the next 75 feet for 25 footcandles on 11-foot average linear spacings; the next 75 feet, 16 footcandles on 16-foot average linear spacings. The 800-foot center section had a design level of 10 footcandles on staggered spacings of 16-foot centers. For the remaining 300 feet, the design of the first 300 feet is reversed, providing 45-50 footcandles just prior to the exit, which, since the tunnel is two-way, is also an entrance.

Nighttime lighting was engineered for even light distribution along the tunnel walls. For the first 138 feet, only one lamp in every fourth opposite fixture is energized; the next 95 feet have one lamp in every third fixture on; the center section, one lamp per fixture, since these fixtures are on a staggered arrangement. The single lamps in the nighttime circuit are uniform in the downward directing of light.

Measured illumination readings after installation showed:

Location	Footcandles
Day Circuit	
Entrance	49-51
300 Feet	25
Center	11
Night Circuit	
Entrance	2.5
100 Feet	6.6
Center	5.3

Sixteen circuits averaging 24 lamps per circuit control the daytime operation of the 185 two-lamp luminaires. For the nighttime lighting, only four circuits are used, averaging 23 lamps per circuit.

Harold Stead of the Arizona Highway Department, Phoenix, designed the lighting for Mule Pass Tunnel, which won second prize in the Arizona Section's 1959 MMILJ competition.

New Look for a Dog's Life

IN THESE DAYS of "dog sitters," mink coats and jewelled collars for rich dogs, even a school for dogs (as reported recently in a staid, respected New York City newspaper), nothing is considered too extravagant for the comfort of "man's best friend." Let it not be thought that illuminating engineers discriminate against this favored animal, for in Collins Veterinary Hospital in Pittsfield, Mass., dogs under observation for rabies spend their days in a newly-built kennel area under 80 footcandles of illumination.

The hospital kennels are in a tunnel-shaped area of cinder block construction, 15 feet wide and 60 feet long. The side walls rise five feet nine inches from the floor, then angle off to about 45 degrees for another five feet. The ceiling starts at this point, runs across the room for seven feet and connects with the angled side wall across the room. Two rows of cages, 64 in all, are installed back-to-back and double-decked in the area.

With no room to recess fixtures in the ceiling, light for the top row of cages is supplied by low brightness, single-lamp fluorescent luminaires with four-foot deluxe cool white lamps, mounted in two continuous rows above the cages. Four-foot modular diffusers provide light control. For the bottom cages, the fixtures are mounted in a continuous row in the knee of the side wall.

After the lighting was installed, the kennels were painted light green and grey, in accordance with best illumination practice, and the average lighting level in the kennel-examination room measured 80 footcandles, 60 per cent more than IES recommends for a general examination room for humans.

The quality of the lighting installation resulted in a time-saving change in the hospital routine. Instead of carrying the dogs back and forth between the kennels and examination room, a push cart table has been put into use to carry the examining equipment into the kennel area and dogs are given their check-ups right in the cages.

With this lighting system and piped-in music to keep the animals contented, it might be said that the dogs at Collins Hospital are "living better electrically" than many people, or so argues Raymond J. Warner, Western Massachusetts Electric Co., Pittsfield, who won first prize in the Yankee Chapter's 1959 MMILJ contest for this job.

Versatile Lighting System For Highway Tunnels

By HAROLD SKOOTSKY
JOHN R. BRASS

A lighting system for highway tunnels which incorporates a luminaire having extra-high-output fluorescent lamps, special dimming ballasts, unusual light control characteristics and unique mechanical features is described. The system was designed to satisfy lighting criteria discussed and summarized in the introductory paragraphs. The phenomenon of "veiling glare" and its effect on daytime visibility into the "dark hole" presented by the usual tunnel entrance, is explained.

THE LIGHTING of vehicular tunnels is, on the surface, a simple matter which becomes somewhat complicated only upon close examination. For example, a still common solution to the tunnel lighting problem is the more or less arbitrary selection of a standard luminaire which is then installed at intervals determined by what is assumed to be a desirable level of illumination.

Some attempt is usually made to intensify daytime tunnel lighting within the entrance, in what is often called the entrance zone, although many engineers hold the belief that the extraordinary blinding effects of sunlight upon drivers looking into the dark entrance cannot be overcome by artificial lighting.

The need for night dimming however, is not always recognized. For example, the I.E.S. recommendations for *Lighting Traffic Tunnels and Underpasses*[5] indicate the night illumination level should be the same as the day level in the central zone. Our comment to this is that if the night level is not excessive, then the same light level during the day is certainly inadequate.

The broad and apparently simple problems discussed above cannot be properly solved by theorizing alone. This would be much like attempting to derive the Fletcher-Munson hearing curves entirely from acoustical theory. The correct light levels for day and night conditions in the entrance and central zones must be arrived at by properly controlled tests using a sizeable group of human subjects. The authors have reported on small scale tests in an earlier paper,[1] and these findings will be summarized later.

The above comments are not intended to imply that most tunnel lighting installations have been thoughtlessly planned. The intention is only to point out what the authors believe is the common practice of relying too heavily on theoretical data and expert opinions rather than controlled tests and observation of conditions at existing tunnels.

For example, it is generally believed and it seems theoretically sound, that daytime visibility into the entrance of a tunnel could be greatly improved by darkening the face of the portal, as well as other surrounding surfaces just outside the tunnel, and the sky in particular, if possible. An ingenious idea developed by J. M. Waldram in England,[2] was to construct a series of large black baffles spanning the roadway, ahead of the entrance (at, say, 100-foot spacing) through which vehicles would pass. These baffles (which could be surfaced with black aluminum honey-comb) would overlap in perspective from the driver's point of view, thereby eliminating sky brightness as well as effectively reducing the average field brightness seen by the driver. But would the driver then be able to see into a relatively dark tunnel on a bright day? Theoretically, yes; actually, no. The series of baffles would of course have little or no effect (depending upon the time of day) on the intensity of sunlight falling on the dust and exhaust fumes in the air between the driver and the entrance. The apparent brightness of this body of contaminated air is in the range of 50 to 100 footlamberts when seen from a point 200 to 300 feet ahead of a tunnel entrance. This bright haze actually veils the entrance and makes it impossible to discern vehicles within a relatively dark tunnel entrance. The effect is com-

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parable to the veiling glare of daytime reflections in store display windows and was apparently discovered independently and almost simultaneously here[1] and in England by Waldram, who then abandoned his earlier idea of entrance screens or baffles.

An idea somewhat similar to the entrance baffles is represented by the light control louvers of Romaine Meyers.[1,3] This installation, however, prevents direct sunlight from falling on the fine particles (aerosols) suspended in the air beneath the louver, while at the same time allowing diffuse light from the North sky to light the approach wing walls and roadway.

Existing Artificial Lighting Systems Of Advanced Design

Although the authors do not know of any existing tunnel lighting installation which embodies all features now believed to be essential to a thoroughly satisfactory lighting system, there have been several outstanding jobs. Undoubtedly the most scholarly and original pioneering work was completed by Geenens and Reid about 15 years ago for the 9117-foot-long Brooklyn-Battery Tunnel.[4] Geenens and Reid first recognized that wall brightness was a far more important factor than roadway illumination in producing good visibility in a tunnel.* In fact, they have reported experiments which indicate that for equal visibility of vehicles within the entrance zone, a lighting system directing light initially to high reflectance sidewalls requires less than one-half the light and power needed for a system which directs light to the roadway. Geenens and Reid also developed the first continuous line, fluorescent lighting system for the Brooklyn-Battery Tunnel, providing quite uniform wall and ceiling brightness, relatively low glare, high efficiency and unusual maintenance features. As with all good ideas, refinements are inevitable, so that today new developments in lamps and ballasts and recent findings concerning desirable wall brightnesses indicate that certain improvements can be made in the Brooklyn-Battery type of lighting, such as higher daytime light levels in the entrance zone, increased dimming ratio for night operation and greater light control.

It is difficult to achieve adequate daytime wall brightness in entrance zones with restricted overhead clearance such as found in the Brooklyn-Battery Tunnel. Space is available only for a single row of luminaires in each of the upper corners of such tunnels.

There are several tunnels with high ceilings which have used an impressive array of fluorescent luminaires in the entrance zone. The Croix-Rousse Tunnel in Lyons, France, has in addition to wall-mounted luminaires, an extraordinary installation of 25 rows of 8-foot, 150-watt, high-output lamps in an 180-foot-long ceiling panel in the entrance zone. In spite of the dark stone walls, the inefficiency of closely spaced lamps and uncontrolled light output, this system must certainly be very effective. However, lighting systems of this "brute-force" type are justifiable only if very great emphasis is placed on the aesthetic value of natural stone walls and luminous ceiling panels.

Tests Made in Tunnels With Good and Poor Lighting

As mentioned above and as described in an earlier paper,[1] numerous visibility tests have been made at existing tunnels in the San Francisco Bay Area. Two of the tunnels, the Broadway Low Level Tunnel and the Posey Tube, have central zone wall brightnesses in the range of 0.10 to 0.50 footlambert. Others, the Park Presidio, Waldo and San Francisco Broadway Tunnels, have central zone wall brightnesses in the range of 5 to 15 footlamberts. The authors, therefore, have had the advantage of observing lighting installations of widely different quality under varying conditions.

Summary of Findings

(a) Daytime Entrance Zone Lighting

In order to provide good daytime visibility into the tunnel entrance (the "Dark Hole") for approaching drivers, 60-footlambert lower wall brightness is required to clearly silhouette vehicles within the entrance. Fair silhouetting may be obtained with 30-footlambert lower wall brightness.

As described earlier, the veiling glare over a typical tunnel entrance has a brightness, on a sunny day, in the range of 50 to 100 footlamberts. Therefore, it is apparent that the 60-footlambert wall brightness recommended should be increased if conditions at the entrance are favorable to higher concentrations of dust and vehicle fumes. This situation might occur if the approach is upgrade and natural ventilation is poor, especially if traffic is very dense and has a high percentage of trucks. The brightness of the field of view surrounding the entrance has far less effect on visibility into the entrance than the veiling glare discussed above.[1]

The length of entrance zone lighting should be approximately equal to the safe stopping distance for the fastest entering vehicles. A 300-foot-long entrance zone will be adequate for speeds up to 55

*Twenty-three years ago, the lower walls in the Liverpool Tunnel in England were deliberately finished in black.

mph. Much longer lengths of entrance lighting have been recommended by others.[5] These recommendations are apparently based upon the need for slowly reducing the light level down to the very low level central zone lighting existing in older tunnels. However, the recommendation here is based upon central zone lighting which provides nearly instantaneous adaptation after the driver has entered the tunnel. The daytime entrance zone lighting we recommend here is actually more than needed for the driver who has entered the tunnel, but is not so great that the central zone lighting beyond will appear dark. Long adaptation stages are required only if the central zone lighting is inadequate.

(b) Daytime Central Zone Lighting

The lower wall brightness in the central zone should be at least five footlamberts to provide good daytime visibility of vehicles. No tunnel is long enough to allow the retina of the eye to completely adapt to nighttime light levels during the day. Unlike iris adaptation, which occurs in a few seconds, complete retinal adaptation to dark surroundings takes up to 50 minutes.[13] It is therefore necessary to have a much higher level of illumination in the central zone during the day than at night.

(c) Nighttime Lighting

Tests indicate that a lower wall brightness of only ½ footlambert in the entrance and central zones provides good visibility of vehicles during the night. This may be easily proved. The Posey Tube incandescent lighting system, which has wall brightnesses in this range, is very deficient during the day. However, it is not only entirely adequate at night, it is actually more than adequate, as evidenced by the fact that certain circuits are turned off during the night. Therefore the authors emphasize that the high nighttime light levels recommended by others[5] are not required for safety, visibility, comfort or any other reason. A maximum maintained wall brightness of one footlambert is recommended. The high nighttime light level in many existing tunnels is simply the result of installing continuous lines of fluorescent luminaires which (due to inherent limitations) cannot be sufficiently dimmed. It may seem incongruous to recommend lower light levels when the general trend in light levels is upward, but in view of the facts mentioned above, the additional operating cost of higher than necessary light levels cannot be justified.

Objectives of New Design

The California Division of Highways has recently completed the design for a continuous line, fluorescent tunnel lighting system to be installed in several tunnels in the San Francisco Bay Area. These are the Webster Tube, Posey Tube, Existing Broadway Low Level Tunnel (two bores) and the proposed additional bore of the Broadway Low Level Tunnel.

The system has been designed to satisfy, with little compromise, the wall brightness and dimming requirements outlined above, and to be versatile enough for use in any tunnel, especially those with restricted overhead clearance.

Other design objectives may be listed as follows:

(1) Special light control characteristics to provide relatively uniform wall and ceiling brightness.

(2) Lamps shielded from drivers' view.

(3) Dust and spray-tight luminaire construction without sacrificing ease of relamping.

(4) One piece plastic cover which can be easily removed for thorough cleaning and does not require a metal frame or other hardware attachment.

(5) Branch circuit or feeder wireway within luminaire shell to eliminate expense of separate wireway (or conduit with outlet boxes) and to facilitate installation in existing tunnels.

(6) High voltage branch circuits to eliminate auto-transformers in ballasts and reduce line losses.

(7) Easily accessible high quality, unity power factor ballasts.

(8) Heat "sink" ballast mounting.

9) Free air circulation behind luminaire shell to cool ballast and reduce air temperature in unit.

(10) Highest quality, corrosion-resistant construction to reduce maintenance expense to a minimum.

Need for New Luminaire Design

Since to this date no commercially available tunnel or underpass luminaire satisfies more than a few of the above requirements, it became apparent, when work was started on the lighting system for the Webster Tube, that a new type of luminaire was needed. Therefore, it was decided to design a suitable luminaire, primarily to determine if the numerous special features could actually be obtained in a practical unit.

The first step was to examine the various types of lamps, ballasts and power distribution systems and select those best meeting our requirements.

Lamps

The most suitable lamp for tunnel lighting should have a small diameter (to increase efficiency of multi-lamp luminaires and allow effective light control), high maximum light output (particularly for entrance zones) and should provide stable operation at very low light output. The first and second requirements are, of course, incompatible. The high-current, rapid-start lamps with T-12 bulbs are a quite satisfactory compromise. For entrance zone

luminaires, the 1.5-ampere, T-12, rapid-start lamps are desirable in order to keep the number of lamps per luminaire to a minimum. It is unfortunate that the lumen maintenance of these lamps is poorer than that obtained with 1-ampere lamps, but since lamp cathode filaments can and should be continuously energized in a tunnel, and because lamps will operate at very much reduced loading at night, rated lamp life will be increased by a factor of 2.5 and lumen maintenance will increase by a factor of well over 2.5. Staggered group-replacement on a yearly basis (8700 hours) will, therefore, maintain lumen output of the system at a high level. Staggered group-replacement is necessary because it is not convenient to interrupt traffic for long periods while a large group of lamps is being replaced.

Eight-foot lamps are desirable for their high efficiency and the reduction in the number of lamps to be maintained. Luminaire cost per foot of length is also reduced.

The high-wattage, rapid-start lamps present a considerable problem in most dust-tight luminaires, due to the usual high rise in enclosed air temperature and consequent reduction in light output. Fortunately, power consumption is also reduced, although lamp efficiency does drop. Methods of cooling the enclosed air are cumbersome and ordinarily consume more power than is regained by improved lamp efficiency.

It is hoped that a practical and efficient method of spot cooling the lamps may soon be developed. However, at this time these lamps should be installed only in luminaires of generous dimensions.

High Frequency Operation?

It has long been known that fluorescent lamps operate more efficiently at frequencies which cause the equivalent electrical characteristics of the lamp to approach a pure resistance in behavior.* In other words, at high frequencies lamp ionization becomes stabilized and the lamp no longer abruptly discharges each half cycle in the usual sense. This discharge characteristic rules out simple capacitor ballasts at low frequencies, since the capacitor will pass the abrupt current surge at discharge, producing a very peaked lamp current wave form and poor lumen maintenance. Therefore in a conventional 60-cycle lead-lag ballast, the lead circuit, in addition to a series capacitor, has a series inductance to prevent current surges. At frequencies over 3,000 cycles, the lamp current wave shape, using capacitor ballasts, will be undistorted, but at sine-wave frequencies appreciably below 3,000 cycles (say 420 cycles) it is probable that lumen maintenance will be relatively poor when simple capacitor ballasts are used. Also, the full benefits of high frequency operation are not obtained at a sine-wave frequency of 420 cycles. For example, 96-inch, 1.0- and 1.5-ampere lamps have only a one or two per cent increae in efficiency on 420-cycle, sine-wave power, as compared to a 60-cycle operation.

Only the 420-cycle system using rotary converters can be considered, at this time, for a tunnel lighting load of 100 to 200 kw. We have found that the principal advantages of this system for tunnel lighting are the low cost and small physical size of the ballasts, and the possibility of simple plug-in components. Other so-called advantages of high-frequency systems, such as low ballast losses, transformerless unity power factor ballasts, and economies of high-voltage, three-phase distribution can be obtained in a 60-cycle system.

We believe that the additional cost of rotary converters (including standby converters) for tunnel lighting systems cannot be justified at this time on the basis of low ballast cost and maintenance conveneince, especially if the 60-cycle system is designed for highest efficiency and low maintenance.

Most Suitable 60-Cycle Power System

The type of ballast to be used is inextricably linked with the type of 60-cycle power distribution system to be chosen. To begin with, it is desirable, as it is with high frequency systems, to select a circuit voltage equal to the lamp starting voltage, down to the lowest temperature to be encountered. In this way, the usual auto-transformer of a conventional ballast may be omitted and the size and power loss of the unit reduced.

It is, therefore, fortunate that the minimum starting voltage for the 96-inch, 1.5-ampere lamps is approximately 335 volts at 0F, a value which allows multiple operation with suitable ballasts on 480- or 600-volt circuits. Maximum voltage to ground in each case will be within National Electrical Code requirements of 300 volts or less if the power source is 480-volt star or 600-volt delta with center tap ground on each phase.

Because 480-volt, three-phase power is ordinarily used by tunnel ventilating fans and other equipment, this voltage was chosen as a basis for the design of a special ballast. A schematic of the power distribution system with dimming control circuit is shown in Fig. 1.

Why Special Ballasts?

Special 480-volt, 60-cycle ballasts are required to obtain many of the advantages ordinarily claimed for high frequency lighting, and particularly to obtain the dimming feature mentioned earlier. A relay is incorporated in each ballast to switch lamps

* Efficiency is increased at high frequencies largely due to reduced electrode losses; therefore, heavily loaded eight-foot lamps are least benefitted by high frequency operation. Claims of increased lamp life at a given loading have not been substantiated.

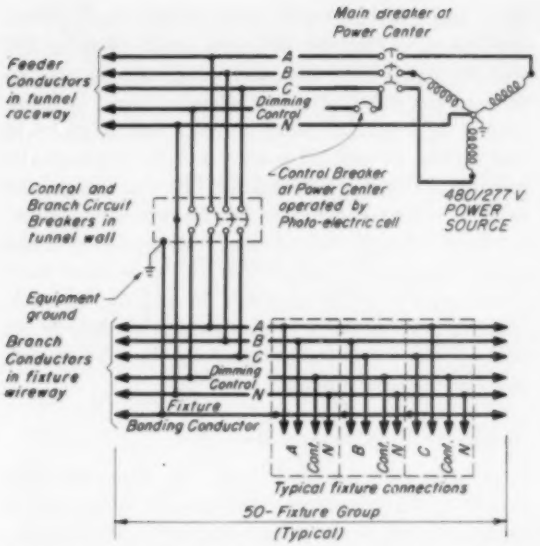

Figure 1. Schematic of power distribution system showing dimming control and typical branch circuit with convenient disconnect in tunnel wall. Where no 480-volt raceway exists, feeders may run in luminaire wireway with each luminaire as a branch with interlocking disconnect.

to the night inductor without interrupting cathode filament current. In entrance zone luminaires, this relay also switches off the upper lamps during night operation, although the cathode filaments continue to operate. The inductors have been designed for low losses, minimum distortion of lamp current wave shape, and long service life. The heater transformer provides the proper cathode filament voltage at all times. An important feature of the ballasts is the location of the power factor correction capacitors, well away from the greatest source of heat, the inductors. A ballast prototype has been thoroughly tested in a three-lamp luminaire prototype and has been found very satisfactory in all respects. In a closed, three-lamp luminaire with all lamps operating at 1.4 amperes in a room with relatively dead air at 70F, the maximum inductor core surface temperature was only 68C. A dimming relay has been given an accelerated life test equivalent to 50 years of service with only the slightest sign of contact erosion.

Certain features of these ballasts which facilitate maintenance are described later.

Features of New Luminaire Design

The design of the luminaire housing and lamp assembly satisfies the objectives outlined earlier and is more fully described below. The cross-section and mechanical operating features of the luminaire are shown in Figs. 2a, 2b and 2c. The luminaire is also adaptable to center mounting in tunnels with high ceilings. In such installations it will provide even better uniformity of wall brightness than when mounted as shown in Fig. 4.

Light Control

Fig. 3 shows the light distribution of a long line of entrance luminaires during the day (see also Fig. 4). The shape of the curve is essentially the same for night operation and for single-lamp luminaires during the day, although the light intensity values will naturally be lower. It should be noted that the flux distribution is given in lumens per radian per foot of luminaire length which is convenient for describing the light distribution from a long line source, because this distribution is symmetrical about a line rather than a point. Candlepower curves for a single luminaire, which must be based on measurements taken at distances over 30 feet from the unit, are completely useless in determining illumination levels and wall brightnesses at distances significantly less than 30 feet from the unit. One of the authors (Brass) developed the unit of cylindrical luminous intensity in 1955 to represent the light distribution of fluorescent sign lighting luminaires in a meaningful way. This concept was first used, apparently, by Einhorn of the University of Capetown, South Africa, in 1951 or earlier.[12]

Simplified Installation with Integral Wireway

One of the most important features of the new design is the accessible integral wireway within the luminaire housing. This greatly simplifies installation of the system, especially in existing tunnels.

The first step in installing the luminaires is to place the brackets which support the two ends of adjacent luminaire housings (see Fig. 5). These brackets automatically align the housing ends so that the extruded vinyl sealing strip can effectively seal the joint. After the housings are in place with seal, the branch circuit conductors (which may be laid out on the roadway) are lifted up into the wireway as cross channels (Fig. 2b) are dropped into place at each joint to hold the conductors temporarily. Connections to the ballasts are then made and the wireway covers installed. The lamp assembly and plastic cover will be packaged separately and installed last.

Exceptional Dust and Spray-Tightness

It is very difficult to imagine the quantity of dirt which can accumulate in a tunnel in a short time. Conditions are far more difficult than for ordinary street lighting luminaires. Conventional methods of sealing tunnel lighting units are not suitable; that is, any method which relies entirely on squeez-

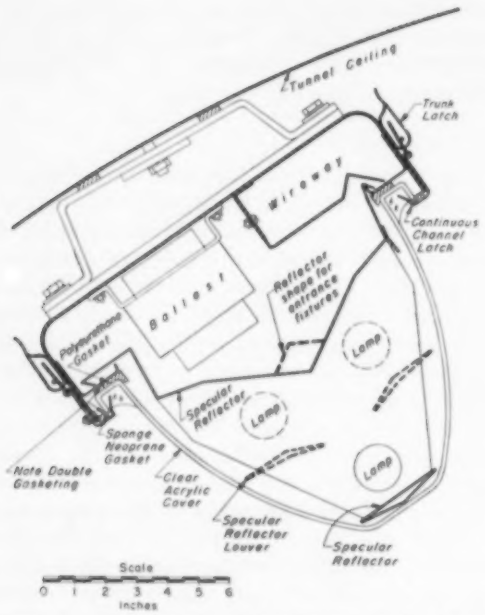

Figure 2a. Cross-section of luminaire. Dashed lamps and reflectors are part of entrance luminaires only. Lamps are 96T12 cool white extra high-output, operated at 1400 ma in entrance zone during daytime; 600 ma in central zone, daytime; lower lamp only at 60 ma throughout, at night.

ing a long gasket between a cover frame and a housing flange, ordinarily develops small gaps in the seal through which dust and water may enter. To prevent the entry of water when a tunnel is being cleaned by a high pressure spray, a double-gasketed and baffled method of sealing a long luminaire is preferred (see Figs. 2a and 5). In this design, the spray of water is deflected by the continuous channel latch from the main gasket and cannot enter the unit. Any water which by-passes the channel latch loses its force and drains out the end of the latch. This latch is operated by three trunk latch type operators which automatically apply the correct sealing force to the gaskets.

Necessary Maintenance Simplified.

As may be noted in Fig. 2c, the lamp assembly can be quickly swung down into the plastic cover to gain access to the ballast and wireway. For further ease of maintenance, the cover may be quickly removed for cleaning. Neither of these operations requires the use of tools.

Electrical maintenance is facilitated by the use of high quality ballasts which are fused to protect the units against excessive current, especially that caused by defective lamps which tend to rectify current through the ballast due to unbalanced ag-

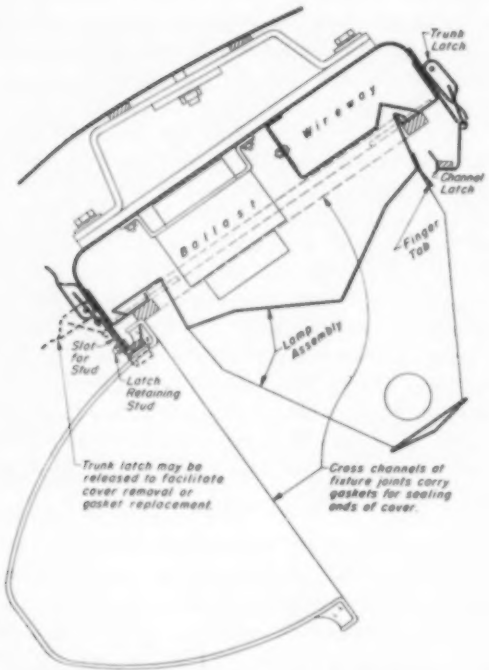
Trunk Latch
Wireway
Channel Latch
Ballast
Finger Tab
Lamp Assembly
Slot for Stud
Latch Retaining Stud
Trunk latch may be released to facilitate cover removal or gasket replacement.
Cross channels at fixture joints carry gaskets for sealing ends of cover.

Figure 2b. Illustration of hinging of cover and operation of latches.

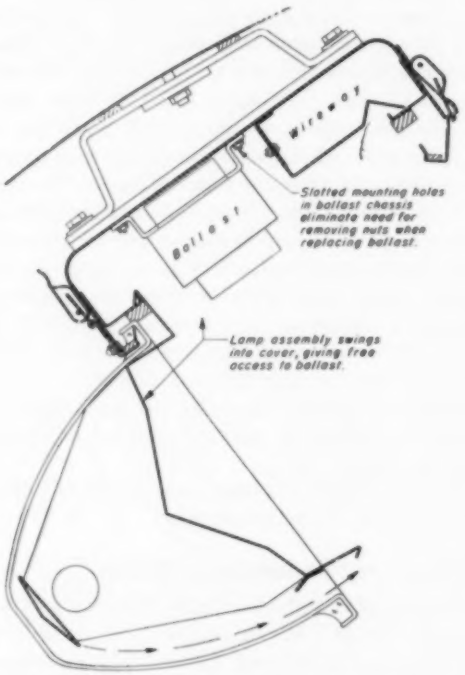
Wireway
Slotted mounting holes in ballast chassis eliminate need for removing nuts when replacing ballast.
Ballast
Lamp assembly swings into cover, giving free access to ballast.

Figure 2c. Lamp assembly swung into open cover for access to ballasts.

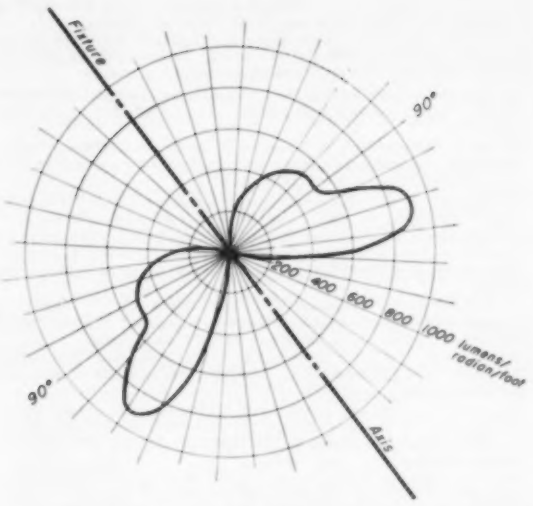

Figure 3. Curve showing cylindrical luminous intensity (I_c) in lumens/radian-foot at center of ten or more three-lamp units.

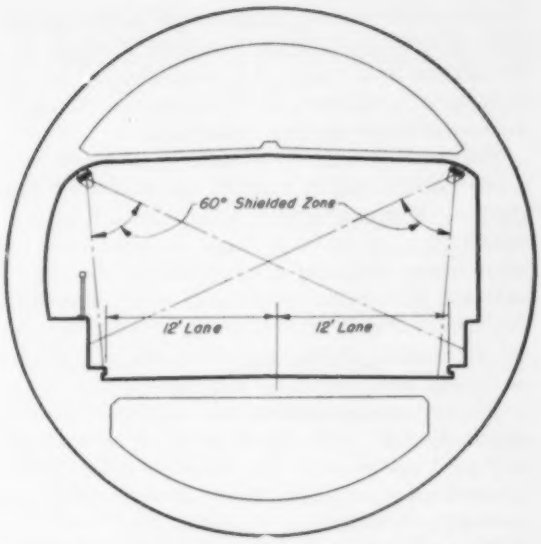

Figure 4. Typical cross-section of tube showing luminaire orientation, shielding and light control.

ing of cathodes. The d-c component through the ballast reduces inductance, causing further increase in current, and so on, until the fuse blows.

Terminal blocks on the ballast chassis allow quick changing of these units. A defective ballast may be taken to the maintenance shop and repaired, rather than scrapped, since components are mounted on a chassis and may be individually replaced. If a capacitor for power factor correction fails, it may be cut out of the circuit and replaced later, without effect on the operation of the luminaire or on overall power factor, although a larger fuse must be installed.

Durable Materials

A luminaire of low first cost may, in the long run, be very costly. For this reason, special attention has been given to design factors which affect reliability.

Mechanical reliability depends to a great extent upon the corrosion resistance of metals used in exterior parts of the luminaire housing. It has been found that aluminum, which is entirely satisfactory in outdoor luminaires, especially if anodized, is not suitable where the luminaire is subjected to the very severe corrosive elements in a tunnel. Some of the unusual causes of corrosion in a tunnel, which have a destructive effect on aluminum, are alkaline deposits from the tunnel lining, concentrated exhause fumes, and especially the rather harsh alkaline solution which must be used to thoroughly clean the tiled tunnel walls. Other problems also arise with aluminum construction. One is the fact that aluminum hardware such as machine screws must be made of high strength alloys which have relatively poor corrosion resistance and which, at best, are weak compared to other metals used for this purpose. Another is the incompatability of most other metals (including the best stainless steels) used with aluminum and the resultant electrolytic corrosion. For equal strength, and where an attempt is made to achieve the best corrosion resistance from aluminum, aluminum construction will be only a little less expensive than all stainless steel construction. This will be true only if the design is adaptable to sheet metal fabrication.

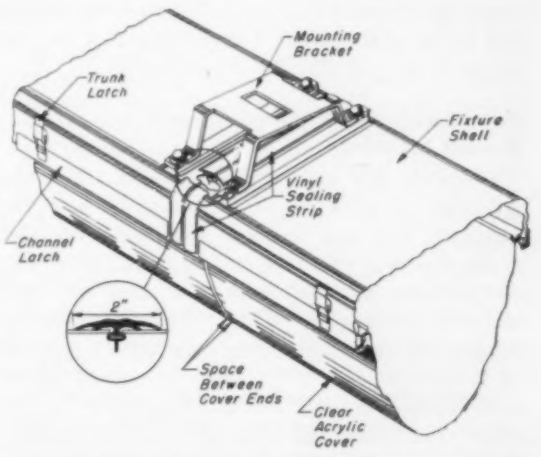

Figure 5. Joint between luminaires showing how mounting brackets support and align the two ends of adjacent luminaire housings so that extruded vinyl sealing strip can effectively seal the joint.

For the above reasons, stainless steel is favored for exterior metal parts of the luminaire housing. Reflectors are to be made of specular-finished aluminum with protective oxide coating as in most fluorescent street lighting luminaires.

The plastic cover is to be made of age-, heat- and craze-resistant acrylic material annealed after fabrication. Every indication is that this will be very satisfactory. Only very high concentrations of alkalies and oxidizing acids attack acrylic. Some care will have to be exercised to avoid scratching the covers during the cleaning process, but all things considered, the acrylic covers will be far easier and safer to handle than glass.

The neoprene gaskets and the vinyl sealing strips are made of long life materials which have unusually good resistance to the effects of aging, water, alkalies, acids, oils, light, heat and weathering, and are relatively free from compression set.

The polyurethane gaskets are not quite as durable as the above materials but they will have longer service life than materials of comparable softness such as latex foam.

Attractive Appearance

As seen from the driver's point of view (Fig. 4) the luminaires will have a unique and attractive appearance. Due to the small (2½-inch) spacing between lamp ends and the very small gap ($\frac{3}{16}$-inch) between the ends of the all-plastic covers, the individual luminaires will not be apparent, and the installation will present a smooth unbroken line. The mounting brackets will be concealed and the latching hardware will not be discernible from the roadway. Since lamps and lamp images are shielded, the plastic covers will appear to "glow" softly with a brightness in the range of 200 to 400 footlamberts. Therefore, the overall range of brightness will be unusually small, contributing to good visibility, comfort and pleasing appearance.

Foreseeable Future Developments in Tunnel Lighting

Certainly the ultimate development in tunnel lighting will be a practical method of achieving luminous walls and ceilings. Installations of electroluminescent wall and ceiling panels may some day achieve this goal with very high efficiency, although low brightness, high cost and installation, wiring and maintenance problems now prohibit use of this system. However, improvements in fluorescent lamps will undoubtedly keep continuous line fluorescent tunnel lighting systems in the forefront for a good many years.

References

1. Trosper, G. A., Skootsky, H. and Brass, J. R.: "A New Approach to Highway Tunnel Lighting," ILLUMINATING ENGINEERING, Vol. LII, No. 3, pp. 137-149 (March 1957).
2. Waldram, J. M.: "The Lighting of Tunnels," *Light and Lighting* (England), Vol. 49, No. 2, pp. 51-56 (February 1956).
3. Meyers, R. W.: "Light Transition Louvers for High Speed Vehicular Tunnels," *Transactions of the Illuminating Engineering Society*, Vol. XXXIV, No. 6, pp. 621-626 (June 1939).
4. Geenens, L. and Reid, K. M.: "Lighting of the Brooklyn-Battery Tunnel," ILLUMINATING ENGINEERING, Vol. XLV, No. 11 (November 1950).
5. I.E.S. Subcommittee on Tunnel and Underpass Lighting, "Lighting Traffic Tunnels and Underpasses," ILLUMINATING ENGINEERING, Vol. LII, No. 6, pp. 325-335 (June 1957).
6. Spencer, D. E.: "Frequency and Fluorescent Lamps," *Electrical Engineering*, Vol. 72, No. 12, pp. 1066-1070 (December 1953).
7. Waymouth, J. F., Bitter, F. and Lowry, E. F.: "Factors to be Considered in the Design of High Output Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. LII, No. 5, pp. 257-261 (May 1957).
8. Gungle, W. C., Waymouth, J. F. and Homer, H. H.: "Operating Parameters of High Output Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. LII, No. 5, pp. 262-272 (May 1957).
9. Campbell, J. H.: "Elements of High Frequency Fluorescent Lighting," ILLUMINATING ENGINEERING, Vol. LII, No. 7, pp. 337-342 (July 1957).
10. Aicher, J. A. and Lemmers, E.: "Design and Characteristics of Fluorescent Lamps Having a Non-Circular Cross-Section," ILLUMINATING ENGINEERING, Vol. LII, No. 11, pp. 579-584 (November 1957).
11. Baumgartner, G. R., Dorsey, R. T., Linsday, E. A.: "Application of Non-Circular Cross-Section Fluorescent Lamps," ILLUMINATING ENGINEERING, Vol. LII, No. 11, pp. 587-596 (November 1957).
12. Einhorn, H. D.: "Sector Flux: A Useful Concept for Practical Lighting Design," ILLUMINATING ENGINEERING, Vol. LI, No. 10, pp. 697-702 (October 1956).
13. McFarland, R. A. and Domey, R. G.: "Experimental Studies of Night Vision as a Function of Age and Changes in Illumination," *Highway Research Board Bulletin 191* (1958).

DISCUSSION

W. E. SCHWANHAUSSER:* The authors are to be praised for their continued interest and pursuit of improvements in tunnel lighting. The theories expressed in this paper, and the installation of the lighting system described, will benefit all those concerned with the challenge of providing adequate lighting in tunnels and underpasses.

Appreciable time is spent explaining the problems of haze brightness at the entrance of tunnels. Apparently the authors' experience has found this to be a major recurrent problem which for one reason or another fails to prove to be a general situation for all tunnels. It would appear that the veiling glare of haze at the entrances would be a function of local atmospheric conditions, the geographical alignment of the tunnel, the time of day and the general effectiveness of the tunnel ventilating system.

The importance of side wall brightness, especially the lower regions, cannot be overemphasized. However, pavement brightness still proves to be an important factor in silhouetting vehicles and cannot be completely ignored. The extent to which the pavement will form the background for the vehicle ahead depends upon many factors which vary with the tunnel design, such as the horizontal and vertical curves of the roadway.

In this respect it is questionable whether such a determined effort should be made to shield the light sources to eliminate all direct light from falling on the roadway and lower sidewalls. Certainly an indirect lighting system should prove quite comfortable, but also somewhat costly from the viewpoint of lower utilization. Perhaps the authors would like to comment on this point, and especially as to the utilization factors of the equipment proposed.

It is further believed that, for those applications where the walls and ceilings of the tunnel are of low reflectance

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or consist of natural rock, direct illumination of the roadway and vehicles is essential to good visibility.

The importance of direct rather than indirect illumination is, of course, paramount during daylight and in the somewhat controversial portal or entrance sections, or where the human eye must rapidly adapt to a lower level of illumination.

Further evaluation of the system described in this paper should prove of considerable interest and real benefit to all of us after it has been installed and operated for some suitable period of time.

R. M. SWETLAND:* The authors have contributed some very constructive thoughts, plus a most interesting luminaire design, toward the improvement of day and night visibility in traffic tunnels.

There occur a few points of both agreement and difference of experience which will be discussed briefly. My experience differs from the authors' on the following points:

Daytime *Portal Veiling Haze*—Many qualified roadway lighting engineers (with considerable tunnel lighting experience) continue to believe that this "veiling haze" is not a "typical" deterrent factor to daytime portal entrance visibility of such a magnitude as to appreciably influence techniques of tunnel lighting and seeing improvement.

Where it does occur, surely it is most variable in degree, markedly influenced by these major factors: (a) local atmospheric conditions and effectiveness of the tunnel ventilating system; (b) whether bright sunlight or mere dull sky-brightness illuminates the outside portal area; (c) compass direction (N-S or E-W) of the tunnel axis, and (d) height and nature of portal ceiling (15 feet horizontal, 22 feet arched or 30 feet funnelled). There are other influencing factors.

To many students of this problem, the *length* of this supplementary entrance zone lighting should *not* be based upon "safe vehicle stopping distance," a mechanical factor rarely experienced at this area, but *rather*, upon the *time* required for effective eye adjustment for *safe seeing*—a factor constantly present. (The IES bulletin, *Lighting Traffic Tunnels and Underpasses*, uses this premise.)

It is a bit disturbing to read the authors' statement that "The high nighttime light levels recommended by others (IES *Lighting Traffic Tunnels and Underpasses*) are not required for safety, visibility, comfort or any other reason."

In many instances now, and it will undoubtedly be more apparent in the future, we believe the advocated "one foot-lambert maximum, maintained, wall brightness" to be inadequate.

I hazard an opinion that Dr. Blackwell's future studies of roadway seeing conditions will substantiate this.

There are, on the other hand, many points of agreement between my experience and that of the authors. Assuming the adequacy of a properly designed 300-350 foot length of entrance zone lighting, the remaining "central zone" brightness during the day undoubtedly should be increased over that which is sufficient at night.

The integral wireway, within the housing, of the proposed new luminaire is an advantageous feature—especially when applied to the relighting of existing tunnels.

The light control of the new design properly emphasizes improved wall and ceiling brightness. The low brightness of the unit is desirable. Luminaires having a more directional (toward-the-pavement) light control are always available, where conditions justify this procedure.

Lamp flexibility (number accommodated) is advantageous and the practically unbroken line-of-light effect is desirable.

I would suggest to the authors that they make the acrylic cover sufficiently durable to withstand flying tire-chain links. (We have winters in Pennsylvania.)

I would also try to shorten the approximate 15-inch projection of the unit down from the ceiling. I believe this is possible, without sacrificing any advantageous features.

Further, use only the most reliable relay available. (Here is a potential trouble source.)

Finally, don't "cut corners" on gasketing and sealing.

Could a condensed tabulation of (a) lumen output from fixture, (b) total wattage and (c) average brightness on walls and ceiling (Fig. 4), assuming realistic reflectance for the three stages of lamp operation listed in Fig. 2a, be added to this paper?

In the near future, we hope the authors will be able to describe the results for an actual installation of these luminaires in a typical traffic tunnel, especially incorporating photographs of portal entrance visibility under various levels of daylight.

H. F. WALL:* As a member of the Tunnel and Underpass Lighting Subcommittee, I should like to urge everyone to submit accounts of their experiences in this field of lighting. The present IES report on Tunnel and Underpass Lighting is not yet an American Standard Practice. It is only an IES Committee report.

Articles such as the one submitted by the authors are most welcome, and we of the committee hope there will be more by others showing their experiences before an American Standard Practice is published.

I think there might be some interest in a comparison of the committee's recommendation with that of the authors':

In Table A, you can see from this comparison that even the authors of the paper must agree that the Committee's recommendation will provide adequate tunnel lighting. Without question some of the figures are too high and should be revised downward before the recommendation becomes Standard Practice.

As you know, the City of Detroit is very flat, so that the possibility of constructing tunnels is practically nil. However, we do have some underpasses in connection with our expressways, and we have been very interested in the belief held by many engineers that "The extraordinary blinding effects of sunlight on drivers looking into the dark entrance cannot be overcome by artificial lighting."

Recently we made sequence photographs of a dark car entering an underpass. Figs. A, B, C, D, and E show that the car practically disappears, and were it not for the reflection from the bumper and other parts of the car, it would be completely hidden from view on a bright day. Observation by several people at various times indicate that these photographs truly represent what the eye sees. This problem is further complicated by the fact that many drivers wear sunglasses on bright days.

*Pennsylvania Dept. of Highways, Harrisburg, Pa.

*Public Lighting Commission, Detroit, Mich.

TABLE A—Vehicular Speeds 55-60 MPH, Heavy Traffic.

	Skootsky & Brass	IES Recommendation
Entrance Zone Wall Brightness (fL)	No Veiling Glare, 30 fL for 300 feet With Veiling Glare, 60 fL for 300 feet	50 fL for first 450 feet 35 fL for 450-900 feet 20 fL for 900-1350 feet
Central Zone Wall Brightness (fL)	Daytime, 5 fL Nighttime, 1 fL	At all times, 3.5 fL

Figure A.

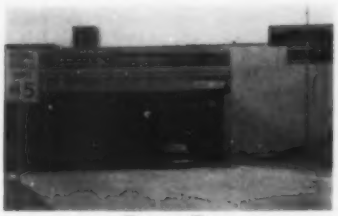

Figure B.

Figure C.

Figure D.

Figure E.

This brings up the matter of light distribution from the ingenious fixture described by the authors. Fig. F shows the distribution curve plotted in the tunnel. Practically all of the light is directed toward the ceiling and sidewalls near the fixture. This means that any viewing of objects in the tunnel will be almost entirely by silhouette against the wall. The photographs of the car entering the underpass indicate that there is a considerable advantage in having some direct light on the cars and other objects, so that by glint, or even direct vision, some idea of the size and shape of hazardous objects is conveyed to the driver. One of the things that is not clear, either in the IES Report or in the authors' paper, is the procedure for measuring footlamberts brightness of the various parts of the tunnel. Should this be done from a point 200 feet out in front of the tunnel, or are these figures supposed to be based on direct reflection at some other angle? It would seem that if we are concerned with visibility, the reading should be taken from a point on the line of sight of an approaching driver.

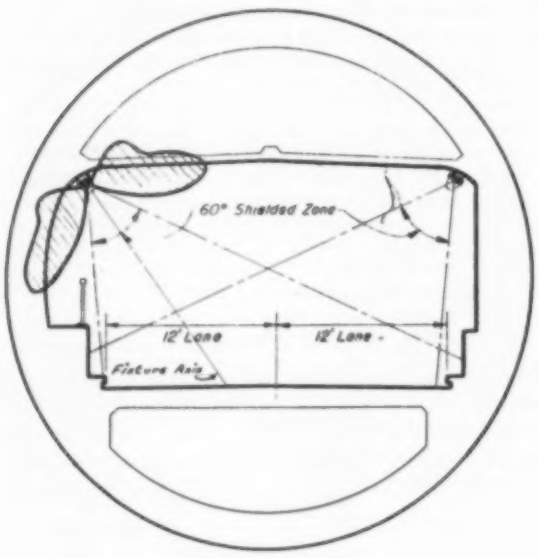

Figure F.

It would be interesting if the authors informed us how they made their brightness measurement; from what point they took their readings, and what instruments were used.

Congratulations again on a most interesting paper — I know that the Tunnel and Underpass Lighting Subcommittee will appreciate all comments on the recommendations as it now stands so that when it is revised for the American Standard it will represent a true standard practice.

J. M. WALDRAM:* It is satisfying that the levels of luminance necessary for safe seeing for both daytime and nighttime lighting of vehicular tunnels were found to be almost exactly the same by the authors and by myself, each working independently. The geometrical conditions, the effects of atmospheric scatter and the fact that adaptation over the ranges involved is nearly instantaneous were also found to be the same. I agree that the use of dark portals and retaining walls is not a solution to the entrance problem, though it may help, as witness the recently constructed underpasses in Brussels. Incidentally, it is as difficult to keep dark surfaces looking dark in a tunnel as it is to keep light surfaces looking light, and they need just as good cleaning. The Brussels installations also demonstrate the possibility of too much light at night in an underpass; their problem is not so much seeing to get into the tunnel by day as seeing to get out of it by night, even with reduced lighting. The main difficulty in England, and it may be in other countries, is to get all these facts across to those responsible for tunnel design, who naturally have a good many other requirements to meet and who may fail to provide one or another of the features essential for adequate seeing.

Recent experience with tunnels and underpasses has indicated that it is unsafe to generalize about methods of lighting, especially entrance lighting. Methods which succeed with one tunnel may not apply to another; and we have found it essential as a first step to set out the approach and entrance in formal perspective from one or two key positions of the driver. The effects of small vertical and horizontal curves may be vital in determining what features of the tunnel form the effective backgrounds and must therefore be made bright. In one tunnel we succeeded very well by providing retroreflecting louvres within the tunnel itself, for

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the walls formed enough of the effective background to be useful.[1] In another tunnel, with a slightly more pronounced vertical curve, we found that the background provided by the walls was too high to be effective, and the important background was the deck of the tunnel. The length of wall which must be lighted for the approach depends so strongly upon the exact geometry that generalizations are apt to be very misleading. All that can be said with certainty is that an approach zone must be provided with such luminance that a driver outside it can see any obstruction within it, and with such length and luminance with respect to the luminance of the tunnel that a driver who has just entered the approach zone can see any obstruction within the tunnel and can stop safely to avoid one which is just inside the portal. We found that it was possible to provide these conditions with a single approach zone for the order of luminances which are expected in England by day and with a reasonable luminance of the tunnel, though the orientation of the tunnel and the local topography may make much difference, according to the positions which the sun may occupy.

In one recent British underpass the preferred design was a louvre, following the idea of Romaine Myers; it was found, however, that by careful design the louvres could be made much smaller and lighter than those, for example, recently installed at the Velsen Tunnel in the Netherlands, where the louvres are some 6 feet deep. By making them inclined an economical construction was possible with a louvre 3 feet deep at the entrances only; it will exclude the sun at all possible positions but will admit enough daylight to provide the correct luminance level. Such a construction is best suited to underpasses approached by a straight or nearly straight cutting, but the length of the cutting may be insufficient to provide the length of approach zone which is required for a safe stop if necessary.

The light distribution designed by the authors is novel, and I await with interest the results in the completed tunnel. The notion of keeping light off the deck is doubtless sound for the level sections of the tunnel; I wonder how it will work at vertical curves at the entrance and exit where the deck may form the most important background.

The form of the luminaire resembles closely those which we have used for many years for street lighting, including the one-piece plastic cover and the soft gaskets compressed by trunk latches or the like. We have found after many years' testing that stainless steel is about the only material which we can rely on to be compatible with aluminum and we use it for catches and details, but have not so far used stainless steel for the body. The continuous wireway proposed by the authors is an improvement upon the device used in Belgium for the continuous handrail lighting of the Namur Bridge (Pont des Ardennes), which involved a terminal strip at each luminaire at which the through wiring had to be broken. The authors also demonstrate that a lighting project such as a large tunnel needs to be thought out in all detail, from the electrical supply and distribution to the minutiae of the lighting fittings, and of the geometry and details of the tunnel itself, if it is to be a proper and successful job.

1. Smith, C. C. and Waldram, J. M.: "The Lighting of Bridges and Tunnels," *Public Lighting* (London), Vol. 22, p. 235 (December 1957).

D. E. SPENCER:* The authors are to be congratulated on having done a remarkably thorough piece of work on tunnel lighting. They have formulated the visual problem in visually significant terms and have even made an intelligent analysis of the possibility of employing high-frequency lighting.

It is most refreshing to hear that tunnel ligting is merely an application in which walls and ceiling of the tunnel should become luminous. It is a delight to hear no mention of footcandle requirements. I would agree that the most practical way of lighting the tunnel walls and ceiling is by means of a luminaire satisfying the criteria suggested by the authors.

The luminaire design described in the paper appears to be a step in advance beyond traditional luminaires. But it is not possible to judge how well the new luminaire satisfies the proposed criteria unless the actual brightness (helios) distribution on the tunnel walls is predicted. The cylindrical luminous intensity curve given by the authors is preferable to a candlepower curve. But both types of candlepower are significant, in this application, only at the distance at which they are measured. Close to the luminaire, the discrepancy between measurements and values calculated on the basis of the authors' cylindrical luminous intensity curves can be expected to differ significantly.

A final comment is to raise the question of whether the optical design employed here is optimum. It would appear that a more uniform distribution could be obtained by employing the macrofocal conic contours described[1] at Toronto last year.

1. Spencer, D. E.: "Controlled Fluorescent Reflector Design for Sharp Cut-off and Uniform Distribution," ILLUMINATING ENGINEERING, Vol. LIV, No. 3, p. 167-174, (March 1959).

D. A. TOENJES:* The design of lighting for vehicular tunnels is growing in importance, as more and more such installations are made. While the authors differ from the recommendations of the IES Tunnel Lighting Subcommittee on certain important aspects of this lighting practice, their report is valuable—perhaps even more so—because of these differences in opinion and the application experience that will result.

Under the topic of "Lamps" the authors have outlined the features that they regard as most desirable for fluorescent lamps to be used in this application. They have chosen 1.5-ampere lamps for the entrance-zone luminaires, in order to obtain the most light output per luminaire for T12 lamps. In their presentation, the authors indicated that certain lamps are operated at currents of 0.600 amperes by day and 0.060 amperes by night. Are those in the entrance zones? If so, just which lamps do the authors recommend for use in the main body of the tunnel—the same 1.5-ampere lamps, or the 1.0-ampere T12 design?

Another lamp design that has recently been made available, having special features that apply well here, is the 1.5-ampere lamp of smaller, T10, bulb diameter. In the eight-foot length, these lamps have a peak light output of about 13,000 lumens, when operated at 1.5 amperes. Their relationship of light output to ambient temperature may be expected to differ somewhat from that of the T12 lamps. However, they may well be found superior for tunnel lighting after a practical method of spot cooling the lamps is developed, as mentioned in the paper. Important features of the T10 lamp design for this application, as compared with the T12 design having the same non-directional bare-lamp candlepower distribution, lie in its reduced diameter and higher brightness, and the resulting improvement in light control and candlepower values from the same size of luminaire.

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*Large Lamp Application Engineering, General Electric Co., Nela Park, Cleveland, Ohio.

The authors have made a realistic comment on spot cooling of fluorescent lamps. It does appear that we are on the threshold of the practical method that they are awaiting, and announcements of such cooling techniques have already been made by various manufacturers of street lighting equipment. Apparently the authors conclude that the more common present-day method is impractical—that of forced-air circulation within the luminaire, and heat transfer to the outside. However, it would seem that tunnel lighting can offer some facilities for this heat transfer that street lighting cannot: less variation in air temperature, and a more constant speed of its circulation past the luminaires; also the possibility of direct thermal connection to pipe conduit or thermal "ground" buried within the tunnel walls.

Whatever method is eventually used for cooling the lamps, it must be remembered that control of light output is not the only consideration. On the basis of performance and useful operating life, it is important to observe also the temperature limits of other components in the lighting system, especially ballast and lampholders.

The use of the "sector flux" concept is interesting, and properly applicable here. The curve (Fig. 3) implies that the luminaires are mounted consecutively end-to-end. However, the center-to-center spacing of the luminaires is not properly applicable here. The curve (Fig. 3) implies that dimension directly, then the sector-flux curve can be applied also for other spacings of this luminaire, in tunnel portions where other wall-brightness values would be preferable.

R. W. Myers:* In the matter of entrance zone lighting of tunnels, the authors of this paper do not believe in theoretical data and expert opinions, but favor controlled tests and observation of conditions. Therefore, I wish to call attention to the entrance control louvers as installed and described in my paper on "Light Transition Louvers for High Speed Vehicular Tunnels," which was presented before the Illuminating Engineering Society conference held in June, 1939.[1]

In reference to the above I quote from the authors' paper: "That this installation, however, prevents direct sunlight from falling on the fine particles (aerosols) suspended in the air beneath the louver, while at the same time allowing diffuse light from the North sky to light the approach walls and roadway." The louvers in preventing direct sunlight on the fine particles of contaminated air reduce the brightness. This is taken advantage of for safe driving visibility by proportioning the roadway length of louvers at entrance of tunnel in relation to the speed of the automobile travel and time of adaptation period of the eye in relation to brightness. See IES papers by Dr. P. G. Nutting.[2,3]

The louvers at entrances to this tunnel (Broadway Low Level, Oakland, California) have been installed for over twenty years with over 170,000,000 automobiles entering and passing through at the legal speed of 45 miles per hour, with very few minor accidents and no deaths. See "The Broadway Tunnel, twin bore called one of the land's safest travel routes" and statement reported of Supervisor in charge since 1938 appearing in "Parade" Oakland Tribune, December 1, 1957.[4]

Tests show that the haze brightness above the louvers is reduced under the louvers to a value that provides comfortable driver entrance visibility, which is attested to by over 170,000,000 automobile drivers. The daytime entrance zone lighting recommended by the authors for good daytime visibility into tunnel entrance is 60 footlamberts lower wall brightness.

The louvers eliminate the installation of an excessive amount of luminaires necessary for 60 footlamberts in the entrance zone, thereby effecting an economic saving in installation, operating and maintenance cost of over $300,000 during a period of thirty years. (See my discussion of "A New Approach to Highway Lighting."[5]

Because of the successful 20-year record of the application of "Light Transition Louvers" to entrance zone lighting as submitted herewith, it is recommended that a careful economic study be conducted concerning outside entrance louvers versus 60-footlambert entrance zone lighting, in the consideration of a lighting system for tunnel highway lighting.

I am in full accord with the authors with respect to favoring stainless steel over aluminum for tunnel luminaires, mentioned under the item "Durable Materials" in their paper. My judgment is based upon personal investigation and examination of the amount of corrosion of Alclad 3003H14 aluminum and 3003H14 aluminum with a protective alumiliting coating. The metals, which were exposed for a period of approximately 20 years to the very severe corrosive elements of tunnels, showed a loss of metal during that period of time of approximately 20 per cent. Examination of stainless steel under similar conditions showed no corrosion.

Overhead entrance zone louvers have been installed recently in a 2,200-foot, four-lane tunnel, located under the Fraser River in British Columbia, Canada. The capacity of the tunnel is 7,000 cars per hour.

I quote the following passage from an article entitled "Light for B. C. Under-River Tunnel" by Karl Haselteiner, Section Engineer, Foundation of Canada Engineering Corp. Ltd.

"The transition from outside high daylight levels to inside tunnel illumination is made possible on an economical basis by providing artificial shadow areas. For 300 feet outside the tunnel entrance, aluminum louvers are placed on concrete beams horizontally, so as to provide no access for direct sun rays. The slanting of the horizontal members of the braced structure is such as to provide a smooth but efficient transition, never exceeding the ratio 1:10 in brightness. These all-important louvers are made of anodized aluminum and the different angles of tilt are calculated so that under no condition in any season will direct sunlight reach the roadway underneath. The louvers do not obstruct any air movement; to the contrary, the reflective surface provides for a cooler area underneath, so inducing draft, which is very welcome to add to the artificial ventilation. This draft eliminates the accumulation of dust particles at the portal, which would give an uncontrolled amount of veiling luminance."

*Consulting Electrical and Illuminating Engineer, Oakland, Calif.

1. Myers, Romaine W.: "Light Transition Louvers for High Speed Vehicular Tunnels," *Transactions of the Illuminating Engineering Society*, Vol. XXXIV, No. 6, pp. 621-626 (June 1939).
2. Nutting, P. G.: "The Retinal Sensibilities Related to Illuminating Engineering," *Transactions of the Illuminating Engineering Society*, Vol. XI, No. 1 (January 1916).
3. Nutting, P. G.: "The Optical Principles of Illuminating Engineering," *Transactions of the Illuminating Engineering Society*, Vol. XV, No. 8, p. 529 (November 1920).
4. Martinez, Al: "The Broadway Tunnel," Parade, *Oakland Tribune*, Oakland, Calif., December 1, 1957.
5. Trosper, G. A., Skootsky, H. and Brass, J. R.: "A New Approach to Highway Tunnel Lighting," *Illuminating Engineering*, Vol. LII, No. 3, pp 137-149 (March 1957).
6. Haselteiner, Karl: "Light for B. C. Under-River Tunnel," *Electrical West* (September 1959).

H. SKOOTSKY AND J. R. BRASS:* The constructive and much appreciated comments presented above most certainly indicate that the science of tunnel lighting is still highly controversial. It is also interesting to note that we have received considerable support on each controversial point, and at the same time no one set of comments agrees entirely with our findings. This situation makes a rebuttal seem superfluous. However, there are a few points which require clarification.

The Basic Lighting Problem

Mr. Schwanhausser and Mr. Swetland do not believe that the described phenomenon of daytime veiling glare exists at all tunnel entrances, and they imply that if it does exist it may be too variable to be a basis for design. In answer, we can only state that, contrary to such beliefs, veiling glare with brightness in the range of 30 to 100 footlamberts will be seen by an observer ahead of any tunnel entrance when (a) the observer (or driver) looks into the tunnnel from 200 feet or more ahead of the entrance; (b) the direct light of the sun falls on the entire area ahead of the entrance, and (c) the air between the observer and the entrance contains only a normal quantity of aerosols (dust and vehicle fumes). These conditions can occur at some time of the year regardless of the tunnel location and orientation, size of the portal, portal design, reflectance of portal and surrounding terrain, ventilation, etc.

In any case, this veiling glare effect has been consistently observed and measured in the San Francisco Bay area and in England by Mr. Waldram.

This still leaves the question of the importance of the veiling glare as a factor in reducing visibility into a tunnel. It is all-important. This is the veil behind which the eye must see. If the brightness of the veiling glare is, for instance, 100 footlamberts, then the tunnel walls must have a brightness of approximately 60 footlamberts for reasonably good visibility of vehicles within. Careful observations, as reported, have proven the truth of the above statement. However, the recommendations of the IES Subcommittee on Tunnel and Underpass Lighting, with which Messrs. Swetland and Schwanhausser agree, indicate that the brightness of the tunnel walls should be one fifteenth of the brightness of the outside portal area (sky apparently not considered). That is, with 9000 footcandles illumination (bright day) on the face of the portal building and surrounding area with an average reflectance of 20 per cent (could be greater), the inside wall brightness should be 120 footlamberts. This is admittedly a very adequate, in fact an excessive, brightness value which has never been achieved in practice. The ratio used in arriving at this figure is somewhat arbitrary and is obviously not based upon any controlled tests. The pitfall of this approach is well-illustrated by the story of Mr. Waldram's baffles.

There is also disagreement on the required length of daytime entrance lighting. Mr. Swetland believes that the entrance lighting should provide for the time required for adaptation to the central lighting. The reasons for this belief are obscure, since the most casual observation upon driving through a relatively well-lighted tunnel on a bright day shows that the only unsolved problem is poor visibility into the so-called "dark hole" when approaching the portal.

Mr. Wall presents photographs to prove that cars cannot be seen by silhouette against the walls of a relatively well-lighted underpass. Although a photographic print at its best can only reproduce a 15 to 1 brightness ratio (even though the original underpass scene had a brightness ratio of probably 40 to 1), we must admit that the vehicle in this case could not be clearly seen against the unpainted concrete walls with brightness certainly no greater than about 15 footlamberts at the mid-point. In such a situation, where inadequate wall brightness exists, glint from the vehicle is of value in seeing that something shiny exists within the "dark hole." Contrary to Mr. Wall's statement, his photographs prove that the size and shape of a vehicle can best be shown by silhouette lighting.

On this same subject Mr. Schwanhausser comments that lighting the walls is a form of indirect lighting. This is indirect lighting only if the final objective is high horizontal roadway illumination. We have adequately covered this point in the paper. The fixture utilization factor which Mr. Schwanhausser requests is an experimentally obtained factor used in calculating horizontal roadway illumination, in which we have only secondary interest. We have stressed that the conventional street lighting approach has led to many poor tunnel lighting jobs.

Messrs. Schwanhausser and Waldram believe roadway brightness is of equal importance to wall lighting in a tunnel with pronounced sagging vertical curves. Since the driver's line of sight extends normally only up to 300 feet ahead of his vehicle, a vertical curve would have to be extremely abrupt to provide a perspective view within 300 feet significantly different from that seen in a straight tunnel. We have never encountered such extreme vertical curves in a tunnel. Incidentally, we do not ignore roadway brightness; we only wish we could use the available light to achieve higher roadway brightness and still have enough left over to properly light the walls and ceiling.

Mr. Swetland also does not agree that a nighttime wall brightness of one footlambert will be adequate. We repeat that tests indicate a wall brightness of only one half footlambert would provide excellent visibility compared to the best conventional street lighting system.

Optical Design Luminaire

Dr. Spencer suggests that the light control characteristics of the luminaire might be improved by using reflector shapes more closely resembling her controlled fluorescent reflector design. Actually the reflectors in the tunnel luminaire are identical in principle to Dr. Spencer's design, even though they are made of straight sections and are much smaller than the reflector in her rather large single-lamp luminaire.

It is of course impossible in a luminaire of necessarily moderate dimensions (especially the three-lamp version) to provide reflectors comparable in size to Dr. Spencer's design. At the same time Mr. Swetland suggests the luminaire housing might be made smaller.

Dr. Spencer states that the cylindrical luminous intensity curve is applicable only at the distance at which it is measured and that it is a type of "candlepower." The unit of cylindrical luminous intensity has been devised and used precisely because it is not a unit of candlepower and is applicable at all distances from a long line source ($Ep = Ic/D \cos \beta$—note that D is not squared). We agree that very close (less than two feet) to a long line of tunnel luminaires, calculated illumination levels, ignoring interreflections, will be significantly erroneous because the luminaires do not then approximate a thin line source. In answer to Mr. Toenjes, concerning luminaire spacing, these luminaires can only be placed end-to-end in a continuous line and the unit of cylindrical luminous intensity is strictly applicable only to a continuous line of light.

We have attempted to predict the apparent brightness (Moon's "helios" seen from the driver's point of view) of various points on the tunnel walls, using the cylindrical luminous intensity curve and the interreflection method, as

*Authors.

TABLE A — Lamp Lumen Output and Ballast Input Power for Entrance and Central Zone Luminaires.

	Three-Lamp Luminaire		One-Lamp Luminaire	
	Day	Night	Day	Night
Lamp Current	1.4a	60 ma	600 ma	60 ma
Total Lamp Lumen Output	40,000*	1200	6900	1200
Ballast Watts	723*	30	131	30

*Will vary considerably with ambient temperature and tunnel ventilation.

suggested by Dr. Spencer and Mr. Swetland. However, one of the simplifying assumptions essential to interreflection calculations does not apply in a glossy tiled tunnel. That is, the reflecting surfaces are not perfectly diffusing. In fact, to confuse matters further, glossy tiled surfaces are not entirely specular. We have therefore used the so-called "lumen method" of calculation, with an empirical correction factor based upon measurements in existing tiled tunnels, to predict the approximate lower wall brightnesses.

Lamps and Ballasts

I have provided, in Table A, the information requested by Mr. Swetland.

In answer to Mr. Toenjes, the Webster Tube is to use extra-high-output lamps in the central zone luminaires operated at 600 ma. However, high-output lamps may be used interchangeably, and will operate at somewhat higher current. We are interested in the new T10 fluorescent lamp for tunnel lighting although, as Mr. Toenjes points out, the adverse effects of high operating temperatures in a multilamp luminaire will be even greater than with the T12 lamp until a suitable method of spot cooling is devised. Mr. Toenjes' idea of using the relatively cool tunnel walls as a "thermal" ground is good and worthy of investigation, although it appears at first sight that the thermal connection to the lamps would be mechanically quite complicated.

Mr. Myers has restated his case for entrance louvers. We must agree that in some situations there may be a long-range economic advantage to the installation of an entrance zone of louvers as compared to an entrance zone of artificial light. However, entrance louvers have a serious limitation in that even with tiled walls below the louvers, the maximum south wall brightness which can be maintained is about 45 footlamberts. East, west and north walls will have a maximum brightness of not over 30 footlamberts.

In answer to Mr. Wall, brightness readings we have taken were made along a line of sight normal for a driver. We have used the Spectra Brightness Spot Meter, which is very easy to operate and which gives sufficiently accurate and consistent readings that are, incidentally, quite free from the possible disturbing effects of bright fields surrounding the spot to be measured. Daytime measurements of tunnel wall brightness should be taken inside the tunnel so that superimposed veiling glare brightness will not be included in the reading. Veiling glare should be measured on a very bright, preferably hazy, day, looking into the darkest part of the tunnel from a point 200 to 300 feet ahead of the entrance.

Expressway Lighting for Driving Ease

Four continuous rows of high-output fluorescent luminaires provide between 50 and 60 footcandles in heavily shadowed areas of two main underpasses of the new Vine Street extension of the Schuylkill Expressway in Philadelphia during daylight hours. Drivers scooting in and out of bright sunlight thus have a minimum of eye adjustment. Desired nighttime illumination of eight footcandles is achieved by darkening all but every sixth luminaire, separated by 39 feet, center to center. The luminaires, each with two 72-inch TD17 lamps, are mounted at the top of the side walls of the underpass. Several short underpasses and the open areas between are lighted with similar fluorescent luminaires, also spaced at distances of 39 feet, each side, and producing eight footcandles. In the open areas short poles, supporting fluorescent street lighting luminaires, are mounted on the center crash wall. Photo and data courtesy of General Electric Co.

Relative Visual Comfort Evaluations Of Roadway Lighting

By CHARLES H. REX
J. S. FRANKLIN

With the aid of the Guth Evaluator and an outdoor full-scale roadway lighting laboratory, relative visual comfort studies have been conducted at Hendersonville, N. C. Two years of night testing a representative roadway lighting installation indicates agreement with computed ratings. Observer data was selected by means of an indoor laboratory BCD population study involving 50 people. These data are in agreement with work by previous researchers. Use of the Evaluator provides better understanding of fundamentals involved in improving night use of the public investment in automotive transportation facilities.

ADDED value and increased night use of our multibillion dollar public investment in streets, highways, autos, trucks and buses involves seeing comfort as well as visibility. Improved comfort for the motorist is one of the principal objectives in the advanced design of vehicles and roadways.

"Comfort, convenience and safety are considerations of importance equal to a consideration of capacity in today's highway planning. This concept of adequate facilities requires modern techniques for handling traffic. . . ."

This quotation is excerpted from a recently published, 232-page report to the U. S. Congress on "The Federal Role in Highway Safety,"[1] stating the results of the Highway Safety Study conducted under the direction of Charles W. Prisk, U. S. Bureau of Public Roads.

Urgent Need for Relative Visual Comfort Ratings

Roadway lighting which makes night driving more pleasant and attractive is being numerically rated[5-9,11,12] in terms of visual comfort and relative visibility. These two seeing factors influence motorist opinion, enthusiasm and demand for the installation and modernization of the lighting.

In commenting upon prior work[5,7,8,11] Mr. Prisk wrote on June 12, 1959, "I have only had time to examine the papers briefly, but I do feel that working toward the measurement of relative seeing effectiveness of various systems is desirable."

On the same day, Mr. Joseph Barnett, Deputy Assistant Commissioner for Engineering, U. S. Bureau of Public Roads, wrote: "Based on what you already have accomplished toward the evaluation of highway lighting in the form of relative visibility and visual comfort ratings, I am sure that in the future you will be able to make further improvements toward the rating of seeing effectiveness."

The splendid Highway Safety Study Report[1] includes comment upon the need for evaluation, driver research and engineering investigation and analysis of vision problems and driver fatigue. For example:[1,22] ". . . The Bureau of Public Roads has initiated appropriate cooperative studies with State authorities so that sorely needed new concepts, criteria, and techniques will be developed for determining the true value of continuous lighting on rural highways." Additional pertinent excerpts from this Report are presented in Appendix A.

Visual Benefit Ratings Should Accompany Ratings of Traffic Benefit

In support of such highly significant activities,[2] and plans for research and engineering analysis of the effectiveness of roadway lighting,[3,4] as well as other measures for improvement of night driving conditions, it is obviously essential that relative ratings be available for both visual comfort and visibility.[14-16,21]

If the roadway lighting being appraised in the aforementioned studies[1,3,4] has poor visual ratings, it is obvious that the traffic benefit produced can be

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif. AUTHORS: Roadway Lighting Development Engineer—Advance Engineering and Development Engineer—Photometric Laboratory, Outdoor Lighting Department, General Electric Co., Hendersonville, N. C. Accepted by the Papers Committee as a Transaction of the IES.

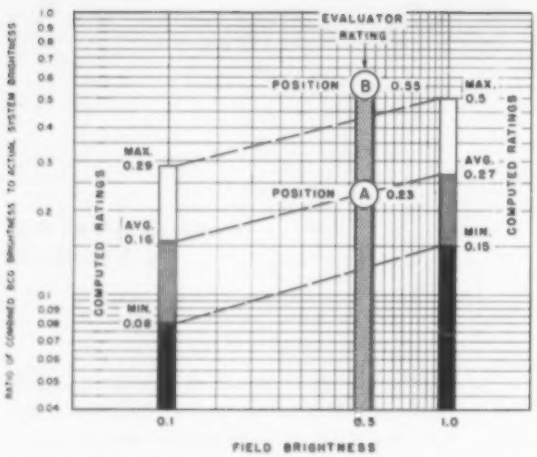

Figure 1. Evaluator relative visual comfort ratings for selected driver-observers at Position A and Position B on the roadway shown in Fig. 2 are presented for comparison with computed ratings.[5] These ratings for similar roadway lighting systems are of similar magnitude even though different BCD methods are involved. Note increase in computed relative comfort ratings with increase in Field Brightness.

expected to be less than that produced by lighting having good visual ratings. Visual ratings now considered good may be considered poor in the future—relics of days when we knew less about the after-dark efficiency of the motorist, his faculties and his motor vehicle transportation facilities. The visual comfort quality of roadway lighting may have implications of equal or greater importance to the over-all public welfare than that known to be the essential in prescribing interior lighting.[17,18] Also of significance are the ratings in terms of relative visual comfort (designated discomfort glare) and relative visibility resulting from studies in other nations—Netherlands,[6] Great Britain[7,8,9] and West Germany.[10]

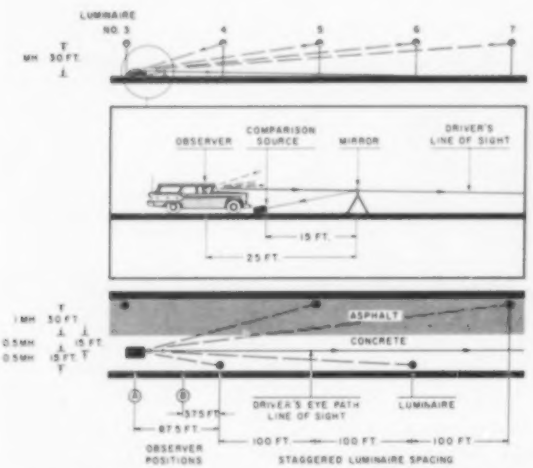

Figure 2. Evaluator observer positions A and B shown with respect to the layout of full-scale roadway lighting system tested. Center inset shows dimensional position of Evaluator components, *i.e.*, comparison brightness and source, mirror, with respect to observer sitting in a representative automobile.

Part I

Outdoor Full Scale Evaluation Of Relative Visual Comfort

The urgent need for the development of additional evaluation techniques motivates this paper which presents the use of the Guth Evaluator for rating the relative visual comfort of roadway lighting systems.[12] Outdoor, full-scale field testing is involved here, as differentiated from ratings based upon a previously described computation method.[5]

Fig. 1 shows relative visual comfort ratings for similar roadway lighting systems derived by two different methods.[5,17] The Evaluator ratings A and B pertain to different driver-observer positions along a roadway lighting system, as shown in Fig. 2. The Evaluator ratings have been derived from a recent selective analysis of data produced by two years of outdoor field testing of a lighting system at Hendersonville, N. C.[13] (Figs. 2 and 3). Observer data were selected on the basis of a BCD "population study," involving 50 people. The study was conducted recently in the Photometric Laboratory at Hendersonville and is described in Part II of this paper. The Evaluator used was

Figure 3. Test roadway,[13] system luminaires, Evaluator mirror and representative automobile at Position A as diagrammed in Fig. 2.

TABLE I—Evaluator versus Computed Method and Resulting Difference in Data for System of Roadway Lighting Luminaires with 15,00-Lumen Multiple Filament Lamps. (All Brightness Data are in Footlamberts.)

		BCD Brightness		Brightness of System Luminaires		Rating Ratios	
Type of Rating	Field Brightness	Avg. $\Sigma\overline{B}$* for System of Luminaires not on line of sight	$\overline{B}_L$** Excluding Luminaires	Avg. ΣB† Actual Luminaires combined	B_L‡ in terms of Line of Sight	$\overline{B}_L/B_L$ Line of Sight	Avg. of $(\Sigma\overline{B}/\Sigma B)$
Computed average of ratios for 14 positions	F = 0.1	3500		24,600			0.16
	F = 1.0	5900		24,600			0.27
Evaluator Full-scale Test Rating	F = 0.5						
Position A			830		3630	0.23	
Position B			1120		2020	0.55	
Simulator Studies in Photometric Laboratory 1959	F = 0.1		417				
	F = 0.5		640††				
	F = 1.0		777				

*Average combined brightness of system luminaires which would be at BCD sensation when mounted in pole bracket location 30 feet above roadway for two assumed field brightness conditions which include the pavement brightness.
**Geometric average of observed brightness of Evaluator source which is at BCD sensation on the observer's line of sight toward pavement. Luminaires are excluded. Evaluator source size is 0.000025 steradian.
†Average combined actual brightness of lighting system luminaires.
‡Geometric average brightness of Evaluator comparison source on line of sight which produces sensation equivalent to that of the combined effect of lighting system luminaires.
††Extrapolation from Fig. 11. Source size is 0.000032 steradian.

developed by Dr. S. K. Guth and J. F. McNelis.[17] The computed ratings are based upon use of a method[5] of rating the relative visual comfort of lighting systems which has been presented during the past year.[5, 11, 12] In this instance, luminaire spacing is 105-foot staggered. The visual comfort ratings shown in Fig. 1 are relative to the motorist-observer sensation which would be at BCD, the borderline between comfort and discomfort, for the system of luminaires and the lighted roadway,[5] or the lighted roadway only,[17] as differentiated in Table I and its footnotes.

The Evaluator[17] BCD brightness, $\overline{B}_L$, is on the observer's line of sight and excludes the combined BCD brightness, Avg $\Sigma\overline{B}$, includes the BCD brightness of the luminaires off the driver's line of sight, in representative pole bracket locations. However, there is some similarity in the magnitude of the rating ratios produced by the two different methods.[5, 17]

Evaluation Rating Method

The Evaluator rating at each motorist-observer viewing position is:

$$\text{Evaluator Ratio at each position} = \frac{\overline{B}_L,\ \text{the brightness of a source on the observer's line of sight which is at BCD sensation brightness with respect to the lighted roadway background excluding luminaires (fL)}}{\overline{B}_L,\ \text{the brightness of a comparison source on observer's line of sight which produces sensation equivalent to the combined brightness of the system of luminaires (fL)}}$$

The Field Brightness in this instance is assumed to be approximately the same as the average pavement brightness along the observer's path, 0.5 footlambert.

The lighting systems for both the Evaluator and computed ratings include the same type of standard production luminaires. The luminaires are typical of those which have been installed and are in use in many portions of the United States and Canada. The projected area of the luminaire sources viewed from each observer position is the same as for a type of luminaire which has been widely used for mercury lamps. The luminaires are at 30-foot mounting heights and are equipped with 15,000-lumen multiple filament lamps. The transverse distances are also the same for both systems, as indicated in Fig. 2.

Computed Rating Method

The computed rating[5] at each of the several successive motorist-observer viewing positions, and for each Field Brightness condition, is:

$$\text{Computed Ratio at each position} = \frac{\Sigma\overline{B},\ \text{the combined brightness of system luminaires which would be at BCD sensation when mounted on the pole brackets with a specified Field Brightness including that of the pavement (fL)}}{\Sigma B,\ \text{the combined Actual brightness of the system luminaires (fL)}}$$

A computed rating designated Avg is the arithmetic average of the ratings[5] over a cycle of 14 observer positions for a longitudinal distance twice

Figure 4. Front oblique view showing test conditions with Evaluator BCD or comparison source near front of automobile, mirror at left and observer in driver position.

the luminaire spacing. Use of the geometric mean of these ratios instead of the arithmetic would change the mean from 0.16 to 0.15 for $F = 0.1$ footlambert, and from 0.27 to 0.25 for $F = 1.0$ footlambert. The arithmetic mean or average is being used for computed ratings[5] and geometric mean for Evaluator ratings.[17]

The computed ratings are shown for two Field Brightness conditions,[5] $F = 0.1$ footlambert and $F = 1.0$ footlambert. The Field Brightness is the average integrated brightness in the driver's field of view, including the brightness of the pavement and objects thereon and nearby. The average brightness of the lighted pavement directly in front of the observer is approximately 0.5 footlambert. If, in addition, the integrated brightness of the luminaire sources is included, the over-all Field Brightness is appreciably increased.

Figure 5. Observer R. K. Drake shows how Evaluator source brightness is remotely controlled from driver position in automobile. Note headrest assembly. During comparison, shield portion is automatically rotated up and down to expose driver's eyes alternately to impact sensation of brightness of system luminaires.

The development of an instrument for the measurement of the combined brightness in the driver's field of view has been actively solicited during the past several years. Dr. Glenn A. Fry, of Ohio State University, has developed such a device for an Illuminating Engineering Research Institute project.[28] B. S. Pritchard of the Ohio State University Institute for Research in Vision completed the instrumentation for field use. This meter has been used in studies conducted by Blackwell.[22]

It is hoped that future footlambert Field Brightness measurements will be made from the driver's eye position in a typical automobile so as to include conditions such as top of windshield cut-off, etc.[5, 11, 12, 14, 16]

In the lighting system for the computed ratings, spacing for luminaires is 105-foot staggered (3.5 MH) instead of the 100-foot staggered arrangement used for Evaluator ratings. The multiple of 0.5 MH spacing facilitates computation using the method presented in detail previously.[5] The data used for computation were derived from laboratory studies at Case Institute conducted by Putnam-Bower[19] and Putnam-Faucett.[20]

The size ω of each luminaire source is computed for the installed pole bracket locations and representative observer viewing positions.[5] Expressed in terms of steradians, the size ω is the visual solid angle subtended at the observer's eye position by the projected area of each luminaire source. These data, listed in Appendix B, include the driver-observer position at longitudinal distance of 3.0 MH. In this instance the top of auto windshield cut-off[5] is assumed to occur at longitudinal distances less than 3.0 MH to correlate with Evaluator position A, shown in Fig. 2. At the latter position, 87.5 feet in front of luminaire No. 4 on the driver's right, this source was in full view of all observers. This was at least partially due to the lean-forward posture assumed by the observers in order to use the headrest supported by the auto steering wheel (Fig. 5).

Using the Evaluator for Rating Roadway Lighting

Use of the Evaluator for rating the visual comfort of roadway lighting involves set-ups similar to those shown in Figs. 2-6. The brightness of the Evaluator source is reflected in the small mirror directly in line with the observer's line of sight, *i.e.*, toward the middle of the concrete pavement background, about one degree below the horizontal. The

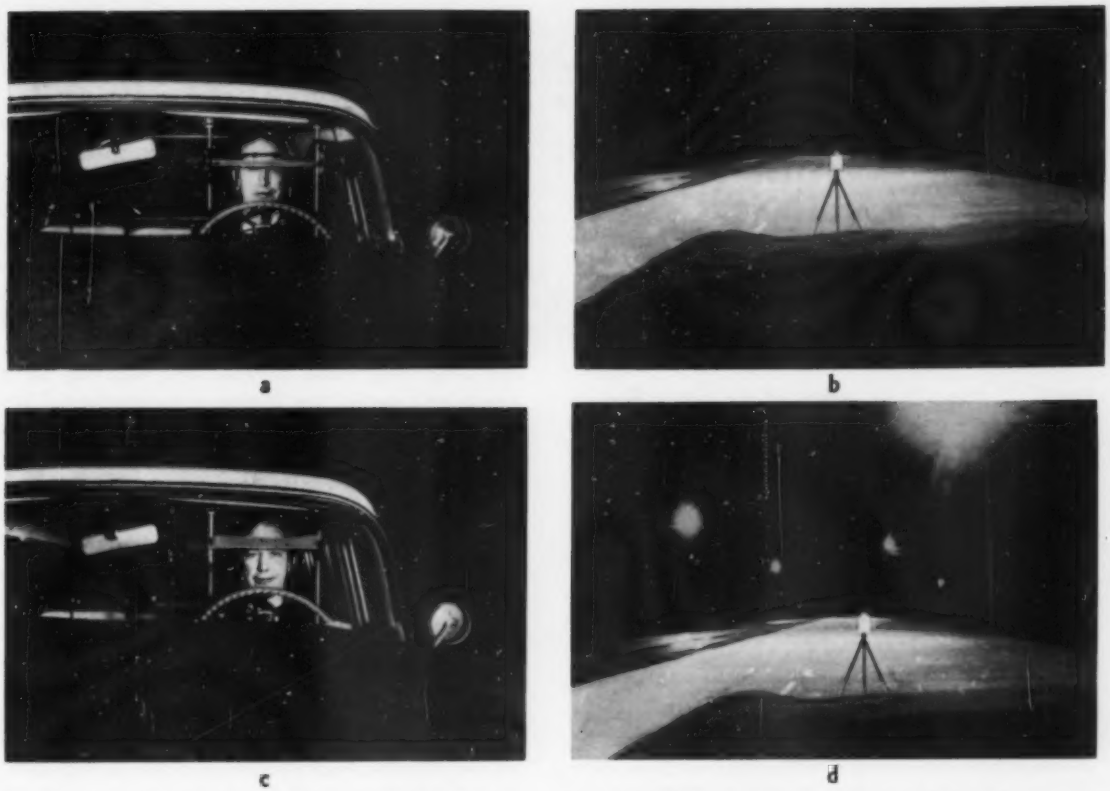

Figure 2. (a) Observer in test automobile with Evaluator headrest shield in the "down" position for appraisal of BCD brightness, $\overline{B}_L$. (b) Resultant cut-off of luminaires and observer's field of view. (c) Shield on Evaluator headrest rotated upward to expose observer's eyes to the combined brightness of the system luminaires. (d) Resultant exposure of luminaires in observer's field of view and Evaluator source at stand-by brightness reflected by mirror. For evaluation of system luminaire brightness, B_L, upper and lower test conditions are alternated automatically. Observer adjusts the brightness of the comparison source, B_L, on the line of sight for an impact sensation judged to be equivalent to the combined brightness of the luminaires.

observer adjusts the brightness of the Evaluator source, shown in Fig. 4, by using the variac remote control, shown in Fig. 5. A flashing sequence is used for the Evaluator source—one second on, one second off, with a two-second break every ten seconds. During the off interval between each exposure, the Evaluator source is lighted to stand-by brightness adjusted to be equivalent to that of the pavement background. The size of the Evaluator source is 0.000025 steradian.

BCD Evaluation

With the movable shield remaining in the down position to shield out the luminaires, as shown in Fig. 6a, the observer adjusts the brightness, $\overline{B}_L$, of the Evaluator source until it is judged to produce the BCD sensation at the borderline between comfort and discomfort. The source brightness reflection is viewed against the field brightness in front of the observer (lighted pavement, some unlighted pavement, roadside and sky, and translucent shield areas, as indicated in Fig. 3 and Fig. 6b). BCD test results are shown in Table I. For observer position A, $\overline{B}_L = 830$ footlamberts on the driver's line of sight.

The average pavement brightness along the driver's path is approximately 0.5 footlambert. This measurement has been confirmed by measurements made by B. S. Pritchard, using a 10-mm aperture brightness meter, during studies[22] conducted by Blackwell.

Evaluator tests have been made to determine the approximate difference in BCD $\overline{B}_L$, brightness, when the shield is raised to expose the observer's eyes to the steady combined brightness of the luminaires, in addition to the pavement brightness. This increases the integrated average field brightness. Nine tests by seven observers indicate that, under this condition, the BCD brightness $\overline{B}_L$, on the observer's line of sight is increased by approximately

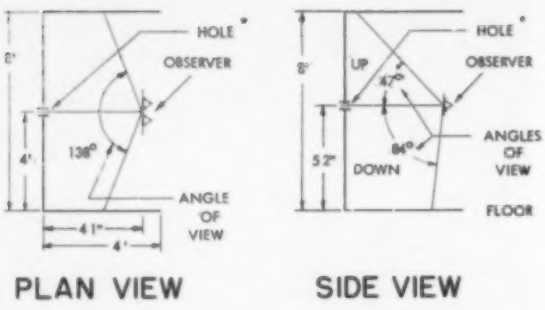

Figure 7. Dimensional sketch of the indoor environmental chamber showing vertical and horizontal angles of view to observers. Light sources to provide background brightness were located to either side of observer at about eye level and were shielded from observer.

twice that when the luminaires are excluded from view. The latter is customary when the Evaluator is used.

Evaluating Brightness of System Luminaires, B_L

To complete each Evaluator test the BCD observations are followed by an evaluation of the combined brightness of the system luminaires in terms of the equivalent impact sensation brightness of the Evaluator comparison source. The shield is rotated upward to expose the brightness of the luminaires to observer view. At this time the comparison source is off, illuminated only to standby brightness. Then the shield is lowered to cut off the luminaires without intercepting the aforementioned portion of the Field Brightness, including the pavement brightness. At this time the Evaluator comparison source is turned on.

The alternate exposure of the observer's eyes to the combined brightness of the luminaires followed by the brightness of the comparison source, B_L, is automatic, regulated by a cam which alternately energizes power to motor operation of the shield, then to the source. The alternate exposures of the system luminaires and the comparison source are of one-second duration, separated by one-second intervals. Three exposures of each (luminaires, and then comparison source) are followed by a five-second period for observer evaluation of the sensations and then readjustment of the brightness of the comparison source. The observer adjusts the brightness of the comparison source until it produces the same impact sensation[17, 18] or feeling as does the combined brightness of the luminaires.

During the evaluation of both the BCD brightness, B_L, and luminaire system brightness, B_L, the observers keep their eyes fixated on the comparison source aperture. The observer is allowed as many cycles as he desires for making an appraisal. During each test five observations are made of each—the BCD brightness, $\overline{B}_L$, and brightness of the comparison source, B_L, equivalent to that of the luminaires. Comparison of the geometric mean of the brightness appraisals, which are both based upon observations on the line of sight, provides the ratio $\overline{B}_L/B_L$ for the relative comfort rating at each position.

Evaluator data for Position A presented in Fig. 1 and Table I for the layout shown in Fig. 2 is based

Figure 8. View of observer (center) in the environmental chamber looking at the flashing spot of light (at upper left). Hand control is located to the observer's right and the brightness meter for making brightness calibrations is at the upper right.

Figure 9. View of rear of environmental chamber (center) showing baffled entrance to chamber (extreme right) and control area at left. Guth Discomfort Glare Evaluator light source box is above and to the right of the large control cabinet.

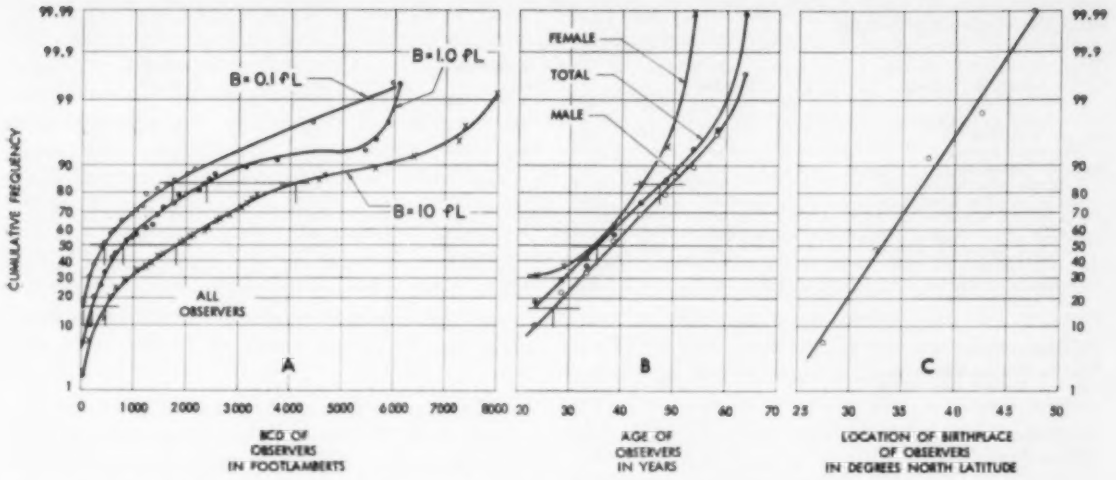

Figure 10. Cumulative frequency distribution plots of various aspects of data on probability paper showing degree of agreement with normal distribution curve (straight line on probability paper).

upon 240 observations by four observers selected as described in Part II. Each of the six ratings made by each selected observer involved ten observations. The mean BCD brightness, $\bar{B}_L$, is 830 footlamberts. The comparison brightness, B_L, with the system luminaires in view, is 3630. This provides a ratio $\bar{B}_L/B_L$ rating of 0.23. The same rating is obtained by taking the geometric mean of the ratio ratings for each of the four observers. For Position B in Fig. 2, the same selected observers were used, but a total of 80 observations and eight ratings are available for the geometric mean.

The selection of observer data on the basis of an average "population study" or BCD brightness evaluation conducted in the laboratory, as presented in Part II, does not necessarily mean that the observers will also make the most authentic Evaluator comparison rating for the combined brightness of the system luminaires. However, "population study" provides valuable guidance.

Also of interest in this respect is the fact that the outdoor full-scale Evaluator studies at Position A for the same filament lamp lighting system shown in Fig. 2 involved 21 observers, including those selected. The 21 observers made 48 relative comfort ratings, or 480 observations. Based upon

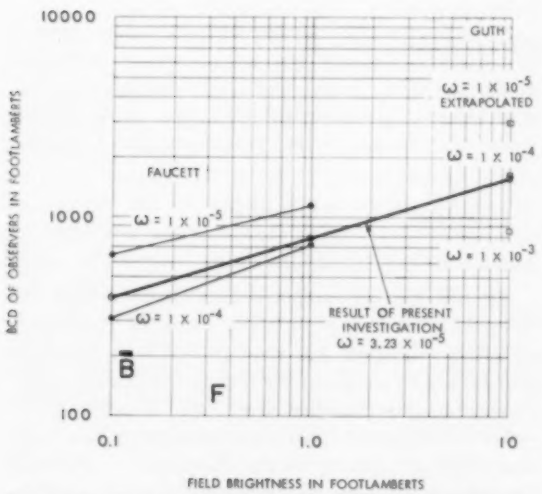
BCD OF OBSERVERS IN FOOTLAMBERTS
GUTH
ω = 1 X 10⁻⁵ EXTRAPOLATED
ω = 1 X 10⁻⁴
FAUCETT
ω = 1 X 10⁻⁵
ω = 1 X 10⁻³
ω = 1 X 10⁻⁴
RESULT OF PRESENT INVESTIGATION ω = 3.23 X 10⁻⁵
B
F
FIELD BRIGHTNESS IN FOOTLAMBERTS

Figure 11. Results of BCD versus field brightness found in the present investigation as compared with results of previous work by Faucett and Guth.

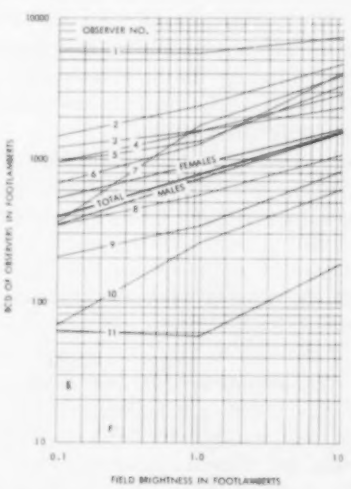

Figure 12. Curves for data on BCD versus field brightness for all male, female and outside nighttime observers, as well as total observer population.

TABLE II—Summary of All Statistical Data Showing Results at Three Field Brightnesses for Male, Female and Total Observers. At Right is Data on Observers versus Age and North Latitude. Lower Part of Table shows Calculated Correlation Coefficients.

Basic BCD Data	Female			Male			Total			North Latitude	Age
	Field Brightness 0.1	1.0	10.0	0.1	1.0	10.0	0.1	1.0	10.0		
No. of Observers	19	19	19	30	30	30	49	49	49	49	49
Arithmetical Averages	1410	1940	2780	850	1230	2340	1090	1480	2510	39°	38.2 years
Geometric Mean G_m	538	892	1630	347	692	1550	417	777	1590	39°	36.4 years
Minimum (G_m values)	30	55	132	9	15	37	9	15	37	28°	21 years
Maximum (G_m values)	4760	6000	7940	5900	5660	7310	5900	6000	7940	49°	61 years
Range (G_m values)	4730	5945	7808	5891	5645	7273	5891	5985	7903	21°	40 years
Median (G_m values)	509	861	1700	398	858	1915	436	861	1840	37.5°	39 years
Standard Deviation σ (G_m values)	1685	2140	2680	1222	1241	1831	1470	1660	2200	4°	10.7 years
Coefficient of Variation V (G_m values)	314%	240%	164%	352%	179%	118%	352%	213%	138%	10%	29.4%
Mode										39.4°	39.5 years
Correlation Data BCD vs. North Latitude Product Moment Correlation Coefficient—r							−0.083				
Correlation Data BCD vs. Age Product Moment Correlation Coefficient—r							+0.12				

all of these data, comprising a larger number of random observers making an unequal number of tests, the geometric mean relative comfort rating is 0.19. This may be compared with the rating of 0.23 by the four selected observers shown in Fig. 1.

Features of Evaluator

The Evaluator may be used to demonstrate and provide better understanding of the fundamentals involved in improving relative visual comfort. A driver-observer, sitting in an automobile, readily adjusts the brightness of the flashing comparison source to the BCD, borderline sensation between comfort and discomfort. By changing the lighting, the driver can observe and readily appreciate the fact that the BCD brightness for a roadway lighting system increases with appreciably higher Field Brightness, including the brightness of the pavement background against which the flashing comparison source is being viewed.

For example, one observer test with the luminaires shielded from view showed an increase in BCD brightness, $\bar{B}_L$, by 4.4:1 when the average footcandles on the pavement were increased in the ratio of 4.6:1. Since the higher level of illumination was obtained with opposite spacing and the lower footcandle level with the staggered spacing shown in Fig. 2, the pavement brightness did not increase proportionately.

An increase in Field Brightness improves the relative visual comfort ratio unless it is accompanied by a corresponding increase in the combined brightness of the system luminaires. The latter may be increased within the limits of the relative comfort ratio without decreasing the relative visual comfort. The Evaluator demonstrates that progress involves higher brightness at or near the pavement level with lower brightness up at the luminaire mountings.

Numerical ratings for the visual comfort quality of roadway lighting are an impelling objective, fully justifying night work. This is an essential step toward increasing the night use of the public investment in automotive transportation facilities.

TABLE III—A Detailed Summary of Statistical Data on BCD versus North Latitude.

	NORTH LATITUDE 25°-29.9°	30°-34.9°	35°-39.9°	40°-44.9°	45°-45.9°
Total Observers	1	3	22	20	3
BCD Minimum	793	436	30	9	94
BCD Maximum	793	5900	4490	4760	2050
BCD Range	0	5464	4460	4751	1956
BCD Median	793	1410	334	555	148
BCD G_m			364	381	
σ			1074	1553	
V			295%	408%	

Part II

Indoor BCD Evaluations

To provide calibration data on our outside observers, an indoor population study of judgments of BCD sensation was made.[24] BCD evaluations were made by means of the Evaluator in a five-sided environmental chamber (see Fig. 7) painted flat white on the inside. This meter and its use have been described previously in the literature.[17] The test procedure included at least two separate settings for each observer. Each setting consisted of five valid BCD evaluations, at each of three background

field brightnesses, with appropriate waiting periods for observer eye adaptation. For example, a minimum ten-minute eye adaptation period was required before any readings could be taken. Although the environmental chamber consisted of one half of an eight-foot cube, very uniform brightness over the visual field (see Fig. 8) was possible with the particular lighting system employed. The Evaluator was placed behind the opening (source size = 3.23×10^{-5} steradians) in the environmental chamber. This source size was a constant throughout the test and represented the same visual angle at 41 inches as the 2⅝-inch diameter Evaluator source size viewed at approximately 41 feet outdoors.

Instructions to the observers on the conduct of the test were read to each person so that all received the same information. Test equipment was set up in a large, black room assuring the necessary quiet and disturbance-free atmosphere required by this type of psychological study. Only the experimenter and the observer were in the room at the time of the observations, with the experimenter located at the rear of the booth (see Fig. 9).

Observers consisted of an all-white population of 52 people, 22 female and 30 male. Age range for the group was 40 years; latitude of birthplace range, 21 degrees in north latitude. During the course of the study, three sets of data (all female) had to be eliminated because of either inconsistent or insufficient data. Thus, results which follow have been drawn from a total of 49 reliable sets of data. Educational background of observers varied from high school to those meeting the Master's requirement at the college level. Observers represented management, office, and factory workers in a typical industrial organization, and were selected to cover a wide range of age (Fig. 10), latitude of birthplace (Fig. 10C), educational background, and sex (Fig. 10B). The degree of success is evidenced in the preceding illustrations. Information on the latitude of birthplace has been included to see if this had any correlation with BCD. In making this attempted correlation, it was assumed that early environment plays a large part in any cause and effect relationship that might exist between BCD and latitude. In addition to the selection of observers by any of the above requirements, all observers participating in the full-scale outdoor night observations of comfort were obviously included.

Results

Fig. 11 shows the excellent agreement between the results of this work compared with those obtained by previous investigations.[20,27] A detailed statistical analysis[25] of the data has been included in Table II. It should be noted that although the arithmetical averages have been included in Table II, the geometric mean (G_m) values have been used throughout the analysis. The equation of the resulting curve (Fig. 11) has been found to be:

$$\overline{B} = 800F^{0.30}.$$

Fig. 12 has, in addition to the curve for the total population, separate curves for (a) all male observers, (b) all female observers, and (c) the eleven outside nighttime observers. As can be seen, at the lower field brightnesses there is a greater difference between male and female observers than at the 10 fL level, with women having a higher BCD value than men by approximately 50 per cent. A study of Table II will show that, although women have approximately the same range of BCD, their standard deviation is greater at all three field brightnesses. These results would indicate a difference in BCD sensation between males and females, particularly at low field brightness, but perhaps a larger population sample would have brought the curves closer to that of the total population.

Although eleven observers volunteered for the outdoor night observations and a large quantity of data have been collected on various observers and street lighting systems, observers 6, 7, 8, and 9 in Fig. 12 have been selected for the purpose of this paper. The geometric mean of the BCD sensations of these four observers at 0.1 and 1.0 foot-lambert Field Brightness falls very close to that of the total population. Data on the other observers have been included so that the range and individual variations can be noted.

Correlation Tests

A correlation test for the relationship of BCD versus latitude of birth gave negative results. Results are summarized in Table II and Fig. 10C. The negative product moment correlation coefficient[26] of —0.083 indicates practically no correlation. The negative sign of r would seem to indicate that whatever little correlation exists is such that a decrease in north latitude is associated with an increase in BCD sensation. Table III shows results of a statistical analysis of the two principal latitude groupings (of which a sufficient number of observers were available). This also indicates very little difference between the two groups of data. A scatter diagram also showed no definite pattern. Fig. 10C, which shows a plot of the data on probability paper, indicates a normal distribution of observers over the range of north latitude covered by the data.

A correlation test for the relationship of BCD versus age was also tried. This too gave negative

results. Results are summarized in Table II and Fig. 10B. The positive product moment correlation coefficient of +0.12 indicates practically no correlation. The positive sign of r, however, would seem to indicate that whatever little correlation exists is such that an increase in age is associated with an increase in BCD sensation. A scatter diagram also showed no definite pattern. Fig. 10B, which shows a plot of the data on probability paper, indicates that a better choice of observers (particularly female) with regard to age could have been made, although male and total populations indicate a normal distribution of observers over most of the age range. The problem, of course, is the inability of finding older men and women within the avenues of approach that were made available to us in the process of selecting possible observers. It should also be noted that the greatest number of drop-outs or rejects from the originally selected observer group were from the female group.

For the variation of individual BCD sensations at any field brightness see Table II for the statistical data and Fig. 10A for a plot of the data on probability paper. All three curves indicate a right-skewed distribution with the values for the geometric mean and median, all below a BCD value of 2000 fL. Readings, however, trailed off to almost 8000 fL.

Summary

Improved environmental conditions for pleasant night driving will involve roadway lighting at locations through, beyond and, in some instances, between centers of population. The effectiveness of this lighting should be high in relative visual comfort and relative visibility rating. Such visual performance ratings should be factored into the traffic operations and driver condition-attitude-performance ratings which have been and will be made.

Much more visual and traffic data, accumulated at a greatly accelerated pace, are essential to implement further progress in night motor vehicle transportation. The use of the best research data, engineering skills, and facilities is imperative.[1]

Relative visual comfort and relative visibility ratings accompanied by traffic benefit ratings will indicate how much better good roadway lighting is when compared with poor roadway lighting or no roadway lighting. Figures of merit for traffic benefit will also help determine the importance of a good relative visual comfort rating compared with or accompanied by a high relative visibility rating.

Interest in the improvement of night traffic conditions is developing. The data presented in this paper provides additional groundwork for future progress in a most vital endeavor.

Acknowledgments

The authors gratefully acknowledge the counsel and assistance of their associates, particularly those who participated in the night tests, population study, computations and preparation of illustrations. Very special thanks to Dr. Sylvester K. Guth, John F. McNelis, Prof. Russell C. Putnam, and the I.E.R.I. Technical Advisory Committee on Light and Vision. Appreciation is extended to A. B. Gough for his preliminary statistical analysis of the Evaluator test data based upon 21 observers, to H. T. Jones for his assistance in conducting the population study and to Miss R. G. Hallows for assistance with computations.

References

1. Strauss, Lewis L.: *The Federal Role in Highway Safety* (House Document No. 93), a report to the 86th Congress, 1st Session, submitted February 27, 1959, results of the Highway Safety Study, Charles W. Prisk, Director, U. S. Bureau of Public Roads.
2. Forbes, T. W., and Katz, M. S.: *Summary of Human Engineering Research Data and Principles Related to Highway Design and Traffic Engineering Problems.*
3. Marsh, Burton W., Chairman, Highway Research Board N.R.C. Night Visibility Committee, forthcoming report: *Research Needed—Better Visibility for Civilian Night Driving.*
4. *The Visual Factors in Automobile Driving*, Report, Conclusion and Plans for *Future Action*, by the Armed Forces—N.R.C. Committee on Vision. Publication 574 by National Academy of Sciences, National Research Council.
5. Rex, Charles H.: "Computation of Relative Comfort and Relative Visibility Factor Ratings for Roadway Lighting," ILLUMINATING ENGINEERING, Vol. LIV, No. 5, p. 291 (May 1959).
6. de Boer, J. B., Burghout, F., van Heemskerck Veeckens, J. F. T.: "Appraisal of the Quality of Public Lighting Based on Road Surface Luminance and Glare," Preprint P-59.23, paper presented at the Sessions of C.I.E., June 15-24, 1959, Brussels, Belgium.
7. Waldram, J. M.: "Report for Committee on Street Lighting, International Commission on Illumination, 3.3.1," Preprint W-3.3.1, presented June 15-24, 1959, Brussels, Belgium.
8. Ruff, H. R., and Lambert, G. K.: "Relative Importance of the Variables Controlling Street Lighting Performance," RLP, 334, Research Laboratories, BTH Co., Ltd., Rugby, England. Attention is suggested to the references used in this paper.
9. Hopkinson, R. G.: "Discomfort Glare in Lighted Streets," *Transactions of the Illuminating Engineering Society (London)*, Vol. V, No. 1, (January 1940). "Evaluation of Glare," ILLUMINATING ENGINEERING, Vol. LII, No. 6, p. 305 (June 1957).
10. von der Trappen, E., Hamburg, Germany: "Electrizitäts Wirtschaft"—"Scientifically Based Streetlighting," *"Strasse und Autobahn—Street and Highway Journal* (1958). "Effort and Results from Modern Streetlighting," *Electrical Management* (1958).
11. Rex, Charles H.: *Ratings for Visual Benefits of Roadway Lighting*, presented at January 6, 1959 meeting of the Highway Research Board Sessions, sponsored by H. R. B. Committee on Night Visibility; Highway Research Board Bulletin.
12. Rex, Charles H.: "Roadway Safety Lighting," a paper and report on behalf of Institute of Traffic Engineers Committee on Roadway Lighting presented at Annual Meeting of the Institute of Traffic Engineers, November 13, 1958.
13. Swetland, R. M., and Tobin, K. D.: "A Demonstration Laboratory for Roadway Lighting," ILLUMINATING ENGINEERING, Vol. LIV, No. 5, p. 265 (May 1959).
14. Rex, Charles H.: *Principles and Figures of Merit for Roadway Lighting as an Aid to Night Motor Vehicle Transportation*, Highway *Research Board Night Visibility Committee, Publication* 438 (1956).
15. Rex, Charles H.: "Improving Seeing Efficiency with Roadway Lighting," *Traffic Engineering* (August 1956).
16. Rex, Charles H.: "Luminaire Light Distribution Principles," ILLUMINATING ENGINEERING, Vol. L, No. 12, p. 586 (December 1955).
17. Guth, S. K., and McNelis, J. F.: "A Discomfort Glare Evaluator," ILLUMINATING ENGINEERING, Vol. LIV, No. 6, p. 398 (June 1959).
18. Guth, S. K.: "Comfort in Lighting," ILLUMINATING ENGINEERING, Vol. LI, No. 2, p. 166 (February 1956). "Quality of Lighting," ILLUMINATING ENGINEERING, Vol. L, No. 6, p. 279 (June 1955).
19. Putnam, R. C., and Bower, K. D.: "Discomfort Glare at Low Adaptation Levels—Part III—Multiple Sources," ILLUMINATING ENGINEERING, Vol. LIII, No. 4, p. 174 (April 1958).
20. Putnam, R. C., and Faucett, Robert E.: "The Threshold of Discomfort Glare at Low Adaptation Levels," ILLUMINATING ENGINEERING, Vol. XLVI, p. 505 (October 1951).
21. Rex, Charles H.: "Technical and Practical Aspects of Highway

Lighting," *Proceedings of the Institute of Traffic Engineers*, Vol. 8, p. 41 (1937)

22. Blackwell, H. R. and Pritchard, B. S.: "Determination of Light Levels for Roadway Visual Tasks," to be presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif.

23. Taragin, A.: *Progress Report on Connecticut Studies* presented at the Jan. 5, 1959, meeting of the Highway Research Board Sessions sponsored by H.R.B. Committee on Night Visibility; Highway Research Board Bulletin.

24. Guth, S. K.: "Causes of Discomfort in Lighting." Preprint W-3.1.1.2, presented at C.I.E. XIV Session June 15-24, 1959, Brussels, Belgium.

25. Arkin, H., and Colton, R. R.: *Statistical Method*, Barnes & Noble, Inc., New York, N. Y. Fourth Edition, Revised (1957).

26. Moroney, M. J.: *Facts from Figures*, Penguin Books, Inc., Baltimore, Md., Third Edition, Revised (1958).

27. Luckiesh, M. and Guth, S. K.: "Brightnesses in Visual Fields at Borderline Between Comfort and Discomfort (BCD)," ILLUMINATING ENGINEERING, Vol. XLIV, No. 11, p. 650 (November 1949).

28. Fry, Glenn A.: Disability Brightness Meter which will integrate and record total brightness viewed by driver. Presented at Illuminating Engineering Research Institute Vision Research Symposium, March 3-4, 1958, Dearborn, Mich.

"Use of the Luckiesh-Moss Visibility Meter for Prescribing Illumination," ILLUMINATING ENGINEERING, Vol. XLVII, No. 7, p. 391 (July 1952).

APPENDIX A—EXCERPTS FROM "THE FEDERAL ROLE IN HIGHWAY SAFETY"*

"Comfort, convenience, and safety are considerations of importance equal to a consideration of capacity, in today's highway planning. This concept of adequate facilities requires modern techniques for handling traffic . . . so that all highway facilities, old and new alike, will function properly. . . .

"Dynamic visual ability has been identified as having special significance for safe driving. . . . Similar research on lighting of highways, bridges, and tunnels, and other light adaptation problems has been or is being conducted by the Bureau of Public Roads in cooperation with State highway departments and others as a means of developing adequate policies for the facilities now in construction. . . . In addition to current research in highway safety, the Bureau of Public Roads is considering plans for new research aimed toward selected areas where more knowledge is critically needed. Proposed projects include investigation of monotony and fatigue problems in expressway driving, more intensive analysis of the driving process, application of human engineering principles to highway design and operation, . . . and improved means for communication from the highway to the driver and among drivers.

"Fatigue is also a common consequence of extended durations of driving, . . . Fatigue has not been clearly defined, especially with reference to highway safety, but it usually refers to the decrement in performance due to depletion of energy reserves—either physiological, psychological, or muscular. . . . Although little work has been done on automobile drivers, 'skill fatigue' may be a fundamental contributor to accidents.

"Fatigue, intoxication, higher speeds of travel, and other factors probably all contribute to the extremely high fatal-accident rate during the hours shortly after midnight, although darkness presumably compounds some of these difficulties for nighttime drivers. Only carefully planned research can determine and measure the contribution of the factors involved and point the way toward night accident reductions.

". . . driver vision is customarily measured by a static test, which has no reliable association with the visual demands upon a driver or object in motion at the time of accident. Means need to be found for improved measures of dynamic visual acuity, of meaningful components of the perceptual fields, and of the driving process itself.

"Thus the driver is often believed to be the principal medium for the improvement of highway safety and yet there is less critical knowledge about him than is known about either of the other two elements. It has been stated that vast sums have been spent on vehicle development, and that highway research though less than adequate has been impressive, but that the real gap in our knowledge is in the understanding of human factors. . . . Thus, there is a very fundamental interrelation between driving and the driver, and the ways in which the demands of the task are adapted to the characteristics of the human being will be a determinant of the safety and efficiency with which the highway-transportation system will function. It is, therefore, very artificial to view the human factors as something distinct and independent of the system in which they must operate. . . . little experimental research has been done on the more fundamental factors of perception, judgment, analysis, decision-making, etc. . . . Thus, it is well known that the human being has definite limits in the amount of information he can utilize per unit of time.

"It does seem apparent, however, that the very nature of the driving task often forces the driver to the very limits of his capacities, thereby increasing the possibility of accident-producing responses. . . . no action takes place on the highway except of his [the driver's] instigation. . . . In long-distance driving, loss of vigilance may become an important factor in driving errors. . . . To fulfill the primary aims of the study looking toward identification of bona fide accident causes, wholly new techniques for scaling and isolating the basic variables must be developed or adopted.

"The investment involved in the planning, design, and construction of a highway dictates that it serve traffic for a substantial period of time. The highway itself is the one permanent structure of highway safety, working 24 hours a day every day in every year to fulfill its public-service function. Obviously, this has both advantages and disadvantages. The highway hazards that are built in, without sufficient regard for human engineering principles, endure in their effect as persistently as do the features that improve safety. . . ."

*A report recently submitted to the 86th Congress, First Session, by the U. S. Secretary of Commerce (House Document No. 93), on the results of the Highway Safety Study conducted under the direction of Charles W. Prisk, U. S. Bureau of Public Roads.

APPENDIX B

TABLE B-I—Appendix Data for Computation of Relative Visual Comfort Each Luminaire. System Luminaires Viewed from Driver Positions along Eye-level line 1.5 MH to the Right of Luminaires, such as No. 3.

Longitudinal Driver Eye-Level Distance		Projected Area of Luminaire Source			Position Factor		$\bar{B}$ or BCD Each Luminaire Source		Luminaire Candlepower Eye-Level 1.5 MH	Actual Brightness Each Luminaire Source		Ratio $\bar{B}/B$ for each Luminaire Source	
in MH	in Feet	Square Inches	ω Steradians	θ Angle of View	F=0.1	F=1.0	F=0.1	F=1.0		Candles per sq. in.	B Footlamberts	F=0.1	F=1.0
3.0	90	122	.00007986	27.3	5.87	3.0	1,608	2,181	6400	52.5	23,730	.068	.092
3.5	105	121	.0000616	25.9	5.39	2.83	1,612	2,074	6300	52.1	23,549	.068	.088
4.0	120	119	.0000487	22.0	4.44	2.57	1,452	2,041	5500	46.2	20,882	.070	.098
4.5	135	113	.0000378	20.3	3.70	2.32	1,336	1,942	5000	44.2	19,978	.067	.097
5.0	150	110	.0000307	18.0	3.06	2.13	1,206	1,870	4000	36.4	16,453	.073	.114
5.5	165	106	.0000249	16.3	2.56	1.97	1,106	1,820	3250	30.7	13,876	.080	.131
6.0	180	105	.0000210	15.0	2.34	1.87	1,090	1,808	2500	23.8	10,758	.101	.168
6.5	195	103	.0000177	13.9	2.16	1.80	1,088	1,825	2250	21.8	9,854	.110	.185
7.0	210	102	.0000152	13.1	2.02	1.76	1,095	1,866	2000	19.6	8,859	.124	.211
7.5	225	100	.0000131	12.3	1.91	1.71	1,112	1,896	1600	16.0	7,232	.154	.262
8.0	240	99	.0000114	11.7	1.84	1.67	1,166	1,936	1300	13.1	5,921	.197	.327
8.5	255	98	.0000101	11.1	1.77	1.64	1,172	1,979	1000	10.2	4,610	.254	.429
9.0	270	97	.00000890	10.6	1.72	1.61	1,214	2,029	800	8.2	3,706	.327	.548
9.5	285	97	.00000800	10.2	1.69	1.58	1,259	2,067	750	7.7	3,480	.362	.594
10.5	300	97	.00000724	9.75	1.64	1.55	1,287	2,099	700	7.2	3,254	.396	.645
10.5	315	96	.00000654	9.34	1.61	1.53	1,333	2,154	650	6.8	3,074	.434	.701
11.0	330	95	.00000588	8.95	1.57	1.51	1,375	2,214	625	6.6	2,983	.461	.742
11.5	345	95	.00000542	8.55	1.53	1.49	1,400	2,254	600	6.3	2,848	.492	.791
12.0	360	94	.00000494	8.2	1.50	1.47	1,443	2,306	575	6.1	2,757	.523	.836
12.5	375	94	.00000455	7.87	1.47	1.45	1,479	2,388	550	5.8	2,622	.564	.911
13.0	390	94	.00000421	7.55	1.44	1.43	1,511	2,392	525	5.8	2,622	.576	.912
13.5	405	94	.00000392	7.22	1.42	1.416	1,551	2,403	500	5.3	2,396	.647	1.003
14.0	420	94	.00000364	7.0	1.40	1.40	1,590	2,488	475	5.0	2,260	.704	1.101
14.5	435	94	.00000340	6.78	1.38	1.39	1,628	2,544	450	4.8	2,170	.750	1.172
15.0	450	94	.00000318	6.58	1.36	1.38	1,666	2,598	425	4.5	2,034	.819	1.277

TABLE B-II—Appendix Data for Computation of Relative Visual Comfort Each Luminaire. System Luminaires Viewed from Driver Positions along Eye-level line 0.5 MH to the Left of Luminaires, such as No. 4.

Longitudinal Driver Eye-Level Distance		Projected Area of Luminaire Source			Position Factor		$\bar{B}$ or BCD Each Luminaire Source			Actual Brightness Each Luminaire Source		Ratio $\bar{B}/B$ for each Luminaire Source	
in MH	in Feet	Square Inches	ω Steradians	Angle of View	F=0.1	F=1.0	F=0.1	F=1.0	Eye-Level 0.5 MH	Candles per sq. in.	B Footlamberts	F=0.1	F=1.0
3.0	90	122	.00008912	17.7	2.90	2.19	763	1,564	6400	52.5	23,730	.032	.066
3.5	105	121	.0000703	16.0	2.56	1.95	732	1,447	6100	50.4	22,781	.032	.064
4.0	120	119	.0000541	14.2	2.19	1.82	688	1,416	5000	42.0	18,984	.036	.075
4.5	135	113	.0000411	12.6	1.94	1.74	677	1,430	3000	26.5	11,978	.056	.119
5.0	150	110	.0000326	11.3	1.81	1.66	695	1,438	2500	22.7	10,260	.068	.140
5.5	165	106	.0000262	10.3	1.69	1.61	713	1,470	1600	15.1	6,825	.104	.215
6.0	180	105	.0000219	9.3	1.63	1.54	745	1,472	1300	12.4	5,605	.133	.262
6.5	195	103	.0000184	8.5	1.53	1.49	757	1,494	1200	11.6	5,243	.144	.285
7.0	210	102	.0000157	7.9	1.47	1.455	784	1,526	1100	10.8	4,882	.161	.313
7.5	225	100	.0000135	7.4	1.42	1.42	814	1,561	1000	10.0	4,520	.180	.345
8.0	240	99	.0000117	6.95	1.38	1.40	848	1,610	850	8.6	3,887	.218	.414
8.5	255	98	.0000103	6.53	1.34	1.38	878	1,654	800	8.2	3,706	.237	.446
9.0	270	97	.00000912	6.12	1.32	1.36	920	1,722	750	7.7	3,480	.264	.495
9.5	285	97	.00000821	5.8	1.30	1.335	956	1,730	700	7.2	3,254	.294	.532
10.0	300	97	.00000742	5.5	1.28	1.32	992	1,774	650	6.7	3,028	.328	.586
10.5	315	96	.00000668	5.2	1.266	1.30	1,057	1,816	600	6.2	2,802	.377	.648
11.0	330	95	.00000601	4.9	1.25	1.285	1,082	1,868	550	5.8	2,622	.413	.712
11.5	345	95	.00000551	4.65	1.235	1.27	1,120	1,909	525	5.5	2,486	.451	.768
12.0	360	94	.0000050	4.4	1.22	1.265	1,166	1,974	500	5.3	2,396	.487	.824
12.5	375	94	.0000046	4.21	1.21	1.25	1,210	2,018	475	5.0	2,260	.535	.893
13.0	390	94	.0000043	4.1	1.20	1.245	1,244	2,065	450	4.8	2,170	.573	.952
13.5	405	94	.0000040	4.0	1.195	1.23	1,289	2,091	430	4.6	2,079	.620	1.006
14.0	420	94	.0000037	3.93	1.19	1.225	1,341	2,163	420	4.5	2,034	.659	1.063
14.5	435	94	.0000034	3.91	1.185	1.22	1,398	2,233	410	4.4	1,989	.703	1.123
15.0	450	94	.0000032	3.9	1.18	1.215	1,441	2,282	400	4.2	1,898	.759	1.202

DISCUSSION

S. K. GUTH:* This paper provides one more step along the way toward solving some of the problems involved in roadway lighting. In all fields of lighting practice, increased emphasis is being placed upon visual comfort, or to put it more accurately, upon minimizing visual discomfort. We have available a considerable amount of laboratory data on direct discomfort glare but need to know more about how this information should be applied to practical lighting situations.

The agreement between the authors' results and those of other investigators (Fig. 11) illustrates the general consistency of the experimental technique. This agrees with our own experience over a period of many years and has given us courage to proceed with the method.

A significant point about the data shown in Fig. 12 is that all observers generally follow the same pattern. Most of the individual curves are approximately parallel. The differences among observers is somewhat greater than encountered by other investigators. However, if the three extreme observers are neglected, the other observers fall within a range of brightness which agrees with other studies.

The plotting of the data in Figs. 10a and 10b doesn't do justice to the data. With the number of observers involved, there can be no point at 99.99. The plot of age of observers will approximate a straight line or normal distribution if this point is omitted.

Since brightness is a logarithmic function, Fig. 10a should be plotted in terms of log BCD. If this is done, the relationship can be represented by a straight line, thus indicating a normal distribution, rather than the skewed distributions as shown in Fig. 10a.

The computations of standard deviation and other values in Table II should be in terms of the logarithm of brightness. This is based upon sound statistical analysis procedures. Furthermore, the standard error of the mean would be more meaningful than the standard deviation. The former is an estimate of the variability associated with the means for the group of observers whereas the latter is an estimate of dispersion of BCD settings for individuals.

Now that the authors have gained some experience with the Discomfort Glare Evaluator, I hope they will continue obtaining data for actual highway lighting systems.

W. S. SMITH:** The paper presented by the authors on "Relative Visual Comfort Evaluations of Roadway Lighting," deals with a most timely need. Certainly, highway officials and others are in dire need of a better means of objectively determining the optimum amount and type of lighting given for surface and traffic conditions. It is the desire of highway engineers to utilize roadway lighting as a means of improving traffic services and safety on major highways; yet, they do not have a method of evaluating different types of lighting and lighting installations by generally approved and accepted methods. The contributions which the authors are making in this connection are to be commended. The work which is reported obviously is based on background data and research conducted over the past five years or more, some of which previously has been reported at the IES technical conferences.

Since "comfort" is a principal objective in all highway transportation, it seems reasonable to include it as a factor in evaluating lighting systems, assuming of course that it will be properly related to the customary evaluation of such factors as intensity and uniformity of illumination.

In planning the illumination of the Connecticut Turnpike for continuous lighting for approximately 50 miles, several experimental installations were evaluated. It was apparent that the measurement of pavement brightness and light patterns left much to be desired in comparing different types of lighting. The desires were best described as "comfort factors," admittedly a rather nebulous matter. The tests in Connecticut indicated that these factors of comfort were not readily recognizable even by experienced consultants except under conditions where extensive miles are illuminated or where repetition of illuminated sections is frequent.

As one interested in traffic operations, I believe Mr. Rex and his associates are on the right track in trying to develop comfort evaluations which take into account the amount of glare or brightness in the over-all aspect of the illumination system. Proper direction of light, screening of the light source, and the borderline situation between comfort and discomfort are obviously the important factors to be considered. Perhaps this is mainly an indication of the contrast of glare between over-all field illumination and the brightness of the individual luminaires. As far as I can tell, this is still a completely suggestive evaluation and, therefore, subject to a wide range of human reactions and suggestions. An objective measurement would be most helpful. Based on the information contained in this paper, it appears that the authors are approaching a method of measurement that can be universally accepted and applied.

From the standpoint of highway engineers, it would be interesting to know whether the measurement will take into account all of the important factors of comfortable seeing. Undoubtedly, Mr. Rex will seek to answer this along with such other important questions as the effects of headlights on field brightness and the relationship between shutter effects and glare. It would be interesting to have more information on these, and also to know how "continuous lamp" lighting installations evaluate in relation to the spacing achieved with conventional luminaires. Comfort comparisons between available luminaires of mercury or fluorescent types should also be made available.

Better means of objectively measuring highway lighting systems would probably be one of the most effective means of encouraging and justifying the more widespread use of highway lighting on expressway and other major highway facilities.

J. W. YOUNG:* I wish to comment in a general way on the paper by Messrs. Rex and Franklin. There is evidence now and then of a growing recognition of the value of comfort in outdoor lighting by more of the people concerned with this necessity. This reaction has been noted as coming from two groups: the lighting industry in producing improved quality in lighting through equipment and application practices and the public, whose actions at times indicate that they believe much of the existing roadway lighting is too glaring.

An important step in improving the quality of lighting is the use of more instrumentation—certainly a major sign of progress—to supplement or augment the results of valid experience and the subjective evaluation procedure relied upon in the past years.

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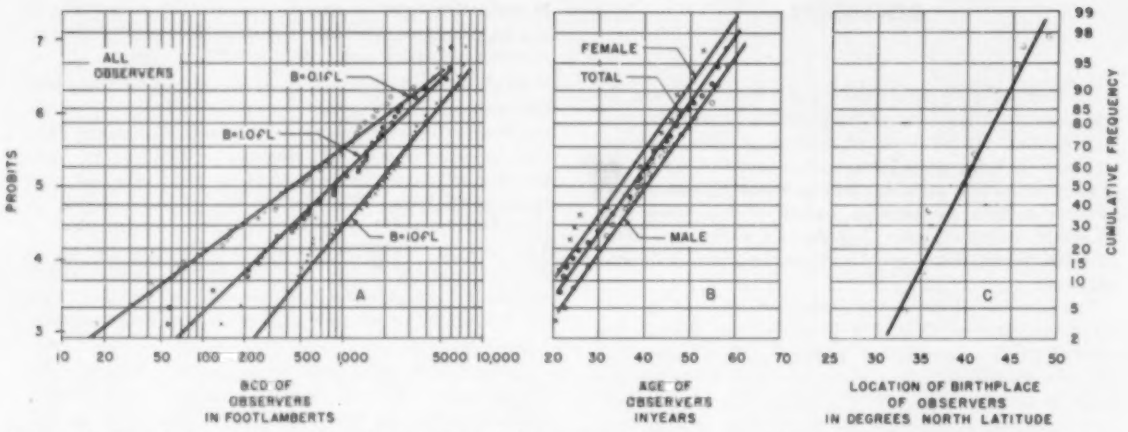

Figure A. Cumulative frequency distribution plots of data on probability paper. BCD plotted on log-probability paper.

I would assume that a further step might be the accumulation of field tests and the sampling of existing installations of roadway lighting as supporting data and the consolidation of such data into a simple form for the use of the application engineer.

We should fully appreciate the amount of work and data contributed by the authors in advancing methods and means of evaluating roadway illumination. It is of real importance and should demand the interest of designers of equipment and users alike.

C. H. Rex and J. S. Franklin:* The many people who contributed to the work which this paper presents appreciate and are encouraged by the discussion support of objectives and recognition of accomplishment.

The suggestions favoring additional testing of roadway lighting systems using the Guth Evaluator are answered in the summary and under the heading "Features of Evaluator" at the end of Part I of the paper. Note the correlation mentioned between increased BCD brightness of the flashing source with appreciably higher pavement brightness (or Field Brightness).

Mr. J. B. deBoer[1] of the Philips Company, Netherlands, says, ". . . the results of the appraisals of discomfort glare in the actual installations . . . indicate that the average luminance of the road surface necessary to reduce the discomfort glare to a satisfactory degree can be represented approximately by a formula. . . ."

Dr. Guth's suggestion has been acted upon by the authors. Fig. A and Table A of this discussion show the laboratory data recalculated and replotted using the statistical and plotting methods suggested in his discussion. Straight line plots show agreement with normal distributions. As seen in Table A, the geometric mean of the BCD is lower in all cases when calculated on the basis of log BCD as compared with values shown in Table II of the paper. Note also that the apparent differences, in standard deviation and coefficient of variation, in BCD evaluations between male and female as seen in Table II become negligible when log BCD is used as a basis for computation, as was done in Table A. From the first part of Fig. A, for any given percentage of observers, one can easily locate the brightness in footlamberts that the observers will accept as being as, or more, comfortable than BCD under the particular existing uniform Field Brightness.

*Authors.

Mr. Smith's last paragraph should alert all those persons interested in improving conditions for night motor vehicle transportation and in raising the standard of night living for night motorists. The significance of the objectives must be appreciated along with the obligation to evaluate or measure the benefits of roadway lighting. Visual or seeing factor ratings are basic. The resultant improvement in traffic operations and the economic gain for the public as well as business interests are dependent upon seeing factor effectiveness.

Recent progress, including other instrumentation now available, and the need for dynamic evaluations, or at least knowledgeable estimates, is presented in "New Developments in the Field of Roadway Lighting," published in *Proceedings* of the 1959 Annual Meeting, Institute of Traffic Engineers, in *Traffic Engineering*, March 1960, and in the 1959 and 1960 reports of the Highway Research Board Night Visibility Committee.

Mr. Young has contributed another constructive and logical analysis of the situation and the follow-up work to be done.

The high quality interest of the discussers in high quality roadway lighting is evident and appreciated.

1. de Boer, J. B., Burghout, F., van Heemskerck Veeckens, J. F. T.: "Appraisal of the Quality of Public Lighting Based on Road Surface Luminance and Glare," Preprint P-59.23, a paper presented at the Sessions of C.I.E., June 15-24, 1959, Brussels, Belgium.

TABLE A—Summary of Statistical Data, Similar to Table II Except Using "log BCD" as the Basic Quantity in all Calculations.

		FIELD BRIGHTNESS								
		Female			Male			Total		
		0.1	1.0	10.0	0.1	1.0	10.0	0.1	1.0	10.0
No. of Observers		19	19	19	30	30	30	49	49	49
Geometric Mean G_M	BCD	457	813	1520	269	576	1350	331	661	1410
	log BCD	2.66	2.91	3.18	2.43	2.76	3.13	2.52	2.82	3.15
Standard Deviation σ (log BCD)		0.61	0.55	0.47	0.66	0.54	0.48	0.66	0.55	0.48
Coefficient of Variation V (log BCD)		24%	19%	15%	26%	20%	15%	26%	20%	15%
Standard Error of Mean $S_{\bar{x}}$ (log BCD)		0.15	0.13	0.11	0.12	0.10	0.09	0.10	0.08	0.07

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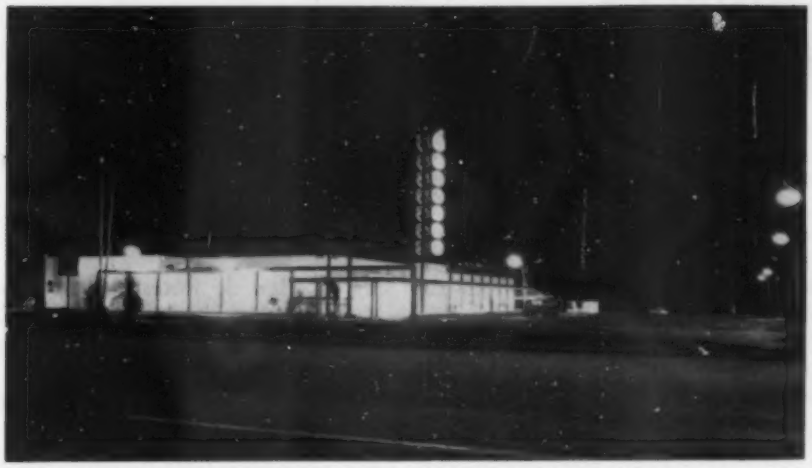

INSTALLATION AT RHONDDA VALLEY SHOPPING PLAZA, SUNNYVALE, CALIF.

Lighting a Shopping Center Parking Area

LIGHTING OBJECTIVE: To illuminate a parking area for nighttime business attraction and to facilitate parking and locating automobiles.

GENERAL INFORMATION: This shopping center and its parking area are located at the intersection of two highways. The parking area is "L" shaped. One leg is 170-feet wide. The other is 190-feet wide.

INSTALLATION: Line Material Industries Line 1C fluorescent floodlighting units are mounted 27 feet above the pavement on twin davit-type Pacific Union Metal poles, as shown in Fig. 2. These twin mounted luminaires, each equipped with two 72-inch T-12 VHO fluorescent lamps, are spaced 110 feet apart along the two legs and are located approximately 45 feet in from the street. The average level of illumination in the parking areas is 1.1 foot-candles.

Lighting designed by Bruce V. Kunde, Lighting Engineer, Line Material Industries, 719 Covington Rd., Los Altos, Calif.

Lighting data submitted by Louis C. Odry, Lighting Application Engineer, Line Material Industries, South Milwaukee, Wis., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

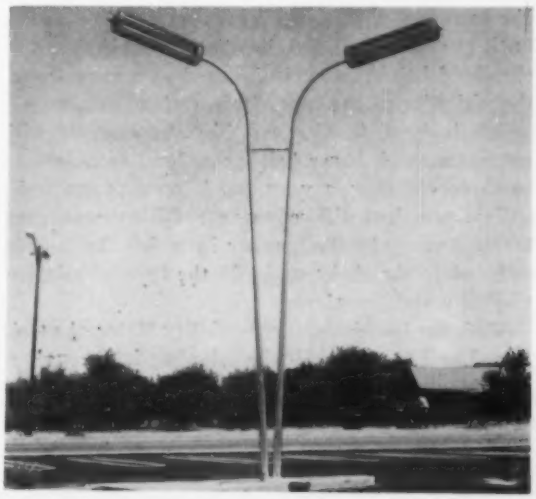

Figure 2. Daytime view showing twin davit-type mounted luminaires.

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Comparison of Visibility Measurement Systems

By A. A. EASTMAN
S. K. GUTH

How do footcandle levels determined with Blackwell's Visual Task Evaluator compare with levels indicated by earlier methods? Relative footcandle levels for equal visibility, as calculated from measurements with the Luckiesh-Moss visibility meter for a variety of visual tasks, are compared in this paper, with footcandle levels for equal performance as determined with the Blackwell Visual Task Evaluator. Reasons for differences between the two sets of values as well as the advantages and limitations of the two instruments are discussed. A method is given for converting the size scale of the L-M meter to a contrast scale as used with the VTE. If it is desired, these converted readings, within practical limits, may be used with Blackwell's performance curves as a basis for establishing recommended footcandle levels.

MEASUREMENT of visibility may be made with several different methods. Currently, measurements with Blackwell's Visual Task Evaluator are being used as a basis for IES footcandle recommendations.[1,2] Formerly, measurements with the Luckiesh-Moss Visibility Meter were used as a basis for many recommendations.[3,4,5,6] Some concern has been expressed regarding the fact that tables of footcandles for equal visibility indicate large differences in magnitude for a series of comparable tasks measured with the two instruments.

The seeming incompatability of the two methods may be attributed primarily to the manner in which basic measurements are modified and interpreted. Differences may be reconciled by a study of the basic measurements taken with the two instruments, since all such measurements are made in terms of one or more of the fundamental factors of size, brightness, contrast and time.

It is a well known fact that the unaided eye is an unreliable judge of the magnitude of the difference in visibility between two visual tasks. The only visibility level which can be judged with any degree of certainty is the threshold level. Some means must be used to reduce the task to threshold by varying one or more of the fundamental factors. For example, if the brightness of a task is reduced until the task is at the threshold of visibility, the threshold brightness may be used as a measure of the visibility of the task. It is obvious that a task which is large in size and high in contrast will require a much lower brightness level to reduce it to threshold than a very small low-contrast task.

Two principal differences in visibility measuring systems are: (1) the manner in which the task is reduced to threshold, and (2) the type of relative visibility scale employed.

With the Luckiesh-Moss Visibility Meter, the task is reduced to threshold by viewing it through a variable density photographic wedge which reduces both the apparent brightness and contrast of the task. The scale of the L-M meter, however, is not in terms of the reduction in brightness and contrast, but in terms of a standard parallel-bar test object which is varied in size. A visual task and a standard test object of specific size are equal in visibility when both are reduced to threshold by being viewed through the same position of the wedge. The sizes of the standard parallel-bar object as seen through various portions of the wedge, under conditions of calibration, are the scale values of visibility for the instrument.[7,8]

With the Blackwell Visual Task Evaluator, the task is reduced to threshold by viewing it through a partially silvered wedge (Finch wedge) in a precise optical system. As the wedge is turned, the contrast of the task varies continuously while the field brightness remains constant. After the task has been brought to threshold with the Finch wedge, a standard luminous disc target against a light background is substituted for the task. Without changing the setting of the Finch wedge, the standard disc target is reduced to threshold contrast by changing the brightness of the disc with a neutral density wedge. The task and standard target are equal in visibility when they are both at

A paper presented at the National Technical Conference of the Illuminating Engineering Society, September 7-11, 1959, San Francisco, Calif. AUTHORS: Lamp Division, General Electric Co., Cleveland, Ohio. Accepted by the Papers Committee as a Transaction of the IES.

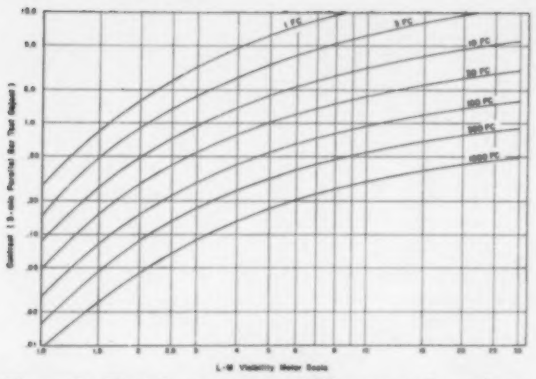

Figure 1. Chart for converting L-M meter scale readings to the contrast of a three-minute parallel-bar test object for various levels of illumination.

threshold when viewed through the same portion of the Finch wedge. The complete range of contrast values of the standard disc is what might be termed the primary scale of the Visual Task Evaluator.[2,9,10]

A scale of size is used with the L-M meter and a scale of contrast is used with the Visual Task Evaluator. Any task which is measured with the two instruments will have two ratings, one in terms of the size of a parallel-bar test object, and the other in terms of the contrast of a luminous disc against its background. *These two ratings must be equivalent if the axiom holds true that things equal to the same thing are equal to each other.* It is therefore possible to determine experimentally the relationship between the two primary scales of visibility. This has been done. The results are reported in this paper.

Conversion Procedure

The first step in relating measurements taken with the two instruments was to prepare a family of curves for converting the L-M meter scale to a scale of contrast values for a disc four minutes in visual size. This is the object used by Blackwell for his standard of comparison with the VTE. The curves, Fig. 1, were plotted from previously reported data obtained with the L-M meter during its calibration and use.[7,8,11] Fry[12] has demonstrated by calculation, that curves of contrast versus brightness, for constant levels of visibility, can be represented by parallel straight lines. Such curves, experimentally determined with the L-M meter, are essentially parallel for the practical range of the instrument. Fig. 1 is a cross plot of a family of curves for a three-minute parallel-bar test object, which, for practical purposes, was found to be equivalent in visibility to a four-minute circular target.

If the two instruments performed in the same manner to reduce a task to threshold, such as both using a variable density wedge, with no diffusion, the set of curves in Fig. 1 would be sufficient to convert L-M meter scale values to the VTE scale values of contrast. They could then be entered directly into the Blackwell performance curves. Since there is a difference, it was necessary to make comparative measurements of the same series of visual tasks with the two instruments, in order to establish the exact relationship. The results of such measurements with a limited number of tasks are shown in Fig. 2. The tasks are described in Table I. Contrast values obtained directly with the Visual Task Evaluator are plotted against values obtained by converting L-M meter scale values to contrast with the curves in Fig. 1.

The correlation is remarkable, considering the fact that the two sets of measurements were made nearly a year apart in different laboratories. The L-M meter readings were made by one of the authors, who also helped in making the VTE measurements. It was hoped that this experimentally determined relationship could have been obtained with carefully controlled conditions, and readings taken successively with the two instruments, without disturbing the lighting or positioning of the task. However, it was not possible to arrange for such measurements to be made.

The relationship between the contrast values ob-

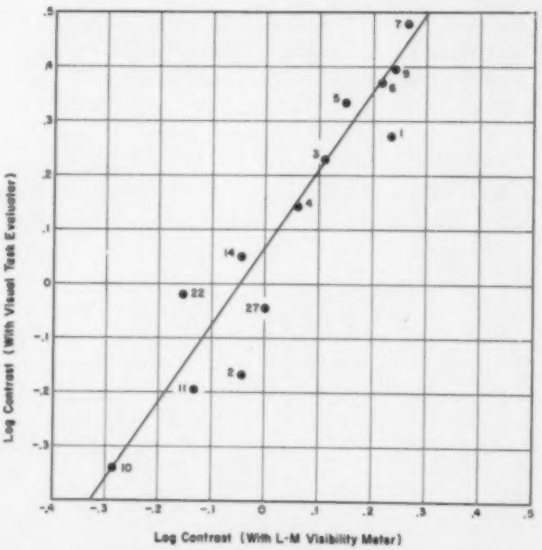

Figure 2. Chart for determining relationship between contrast scale of the VTE and contrast scale of L-M meter, as derived from Fig. 1. Contrast scale of the VTE is for a four-minute luminous disc. Contrast scale for the L-M meter is for a three-minute parallel-bar object, which, for practical purposes, is equivalent in visibility to a four-minute disc.

TABLE I — Visual Tasks* Used for Comparative Measurements of Visual Task Evaluator and Luckiesh-Moss Meter.

Task No.	Description	Average Reflectance
1	Handwriting, ink. One of a group used by Blackwell	.76
2	Handwriting, pencil. One of a group used by Blackwell	.76
3	8-point Bodoni Book Monotype	.70
4	6-point Textype	.70
5	8-point Textype	.70
6	10-point Textype	.70
7	12-point Textype	.70
9	Typing, with new ribbon	.62
10	Typing, with badly worn ribbon	.62
11	Typing, 5th carbon copy	.53
14	Pencil line on tracing paper over blueprint	.59
22	White chalk line on gray cloth	.33
27	Pattern threads, white handkerchief	.91

*The task numbers are those used in Blackwell's report at the IERI Research Symposium in Dearborn, Mich, March 1958, and in subsequent publications. [8, 9, 10]

tained with the two instruments is given by the equation for the straight line plot of Fig. 2.

$$y = 1.43x + .067 \qquad (1)$$

where

y = log contrast, VTE scale

x = log contrast, converted from L-M meter scale (Fig. 1)

The next step is to use the relationship given by equation (1) in replotting the data of Fig. 1, as shown in Fig. 3. This chart is the only one needed to convert L-M meter readings to VTE contrast readings. All that is necessary is to select the footcandle curve corresponding to the footcandles at which the measurements were made, enter the L-M meter scale value into the curve, and read the VTE contrast. This contrast value can be used with any of the Blackwell performance curves.

Application of Conversion Procedure

Since there has been an apparent agreement that the performance curve representing 99 per cent

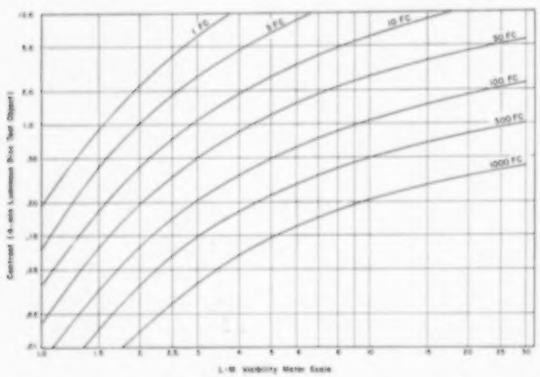

Figure 3. Chart for converting L-M meter visibility scale values at any footcandle level to the contrast scale of the VTE.

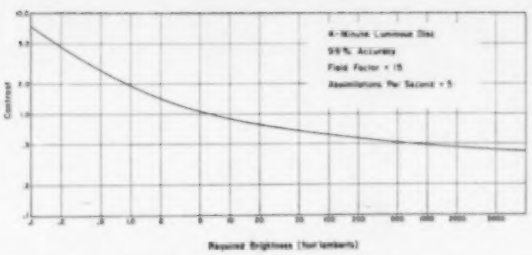

Figure 4. Blackwell's Performance Curve for a four-minute luminous disc.

accuracy, with a Field Factor (FF) of 15 and 5 Assimilations per Second (APS) should be used for all IES tasks, it is the one shown in Fig. 4. It is used in determining the footcandle values given in lines "B" and "C" of Fig. 5.

Footcandles for equal visibility, as determined with the "relative footcandle scale" of the L-M meter,[18] are shown on the bottom line "A" of Fig. 5. Note that the range of office-type tasks is from 15 footcandles for reading 12-point textype to 175 footcandles for reading typing with a badly worn ribbon.

Footcandles for equal visibility, obtained by applying Blackwell's performance curves to L-M meter data, are shown on the middle line, "B." Visibility measurements were made with the L-M meter with 30 footcandles on the tasks. The visibility scale values were then entered into the 30-footcandle curve of Fig. 3 and the corresponding contrast values obtained. These values of contrast were then entered into the performance curve (Fig. 4) to obtain the required brightnesses for a FF of 15 and an APS of 5. The footcandles were determined by dividing the brightness by the average reflectance of the tasks as given in Table I.

The range of footcandles for equal performance for office-type tasks, as given by this procedure, is from about .7 footcandle for 12 point textype to over 3000 footcandles for typing with a badly worn ribbon. These values are in excellent agreement with the footcandle values published in Blackwell[9,10] and IES[2,14] reports for FF = 15 and APS = 5, as shown on line "C" of Fig. 5. This illustrates the validity and practicality of the method for converting from L-M meter scale readings to Blackwell's footcandles for equal performance.

Some of the tasks shown on line "C" (with the VTE) are not arranged in the same order of footcandle requirements as the same tasks on line "B" with the L-M meter. This lack of agreement may be explained by the fact that the tasks were similar, but not the same tasks, or they were the same tasks which were difficult to illuminate and to view in identical manners.

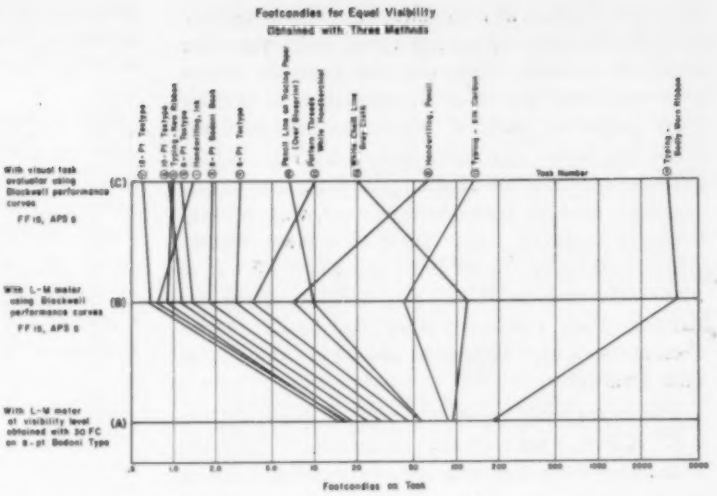

Figure 5. Comparison of footcandles for equal visibility or equal performance, as determined with the Luckiesh-Moss visibility meter and the Visual Task Evaluator. The L-M meter was used with a monocular two-degree field in order to make viewing conditions similar to those with the VTE.

The ink and pencil writing samples were not those used by Blackwell, but were from the same group. Also, it is quite likely that the chalk marks on the fabrics were changed by handling. A slight variation in the angle of illumination, the orientation of the fabrics and the tracing paper over the blueprint can produce a very great change in visibility. Satisfactory comparison measurements of such tasks could only be made in the same laboratory at the same time.

Comparison of Results with L-M Meter and Visual Task Evaluator

The value of footcandles obtained with the VTE and performance curves will not be expected to agree with the values obtained by using the relative footcandle scale of the L-M meter, as shown by a comparison of line "A" with lines "B" and "C" of Fig. 5. However, the tasks should be arranged in the same order of footcandle requirements with the two systems. It seems to be possible to select a combination of Field Factor and APS values which will give the same relative footcandle values for a series of tasks.

The values obtained with the L-M meter relative footcandle scale are footcandles necessary to obtain a specified visibility level, but not directly taking into account the subjective performance of the task. The footcandle values obtained by using Blackwell's performance curves do take subjective performance into account. For example, we can assume that the footcandles necessary to give a task a visibility level of 8 will make that task reasonably easy to perform, because by experience we have learned that tasks with a visibility level of 8 are not considered difficult.

On the other hand, the footcandles recommended for a task, using Blackwell's data, are obtained from curves which take into account not only the Field Factor and accuracy of performance, but also what might be termed the "time factor of performance" (APS) as affected by the complexity of the task. This appears to be the principal reason, from a purely methodological standpoint, why some of the recommended footcandle values from Blackwell's tables differ widely from values obtained with the L-M meter. These differences could of course be resolved by applying the Blackwell performance curves to the L-M meter data, as shown in Fig. 5.

There are other reasons for differences in values obtained wtih the L-M meter and the Visual Task Evaluator. One of these is the difference in wedges used. Without going into detailed discussion, Dunbar[15] has shown that the use of a gradient filter (wedge), varying in density only, will yield results differing from those obtained with a wedge varying in diffusion only. The wedge used in the L-M meter varies principally in density, but a slight amount of diffusion is also present. With the VTE system, the effect is similar to that of a variable density wedge with no diffusion. Differences in values arising from the differences in wedges can be compensated for by the use of curves obtained by direct comparison of readings taken with the two instruments (see Fig. 2). The character of this relationship is in agreement with Dunbar's discussion of visibility meter characteristics.

There are other differences between the two instruments which cannot be so readily compensated for. An important one is the field of view of the two instruments. The field of view of the VTE is two degrees monocular and the field of view of the L-M meter is approximately ten degrees binocu-

iar, when shielded as recommended.[8] This difference is not troublesome with many visual tasks when fine detail is involved. However, for example, where long thin lines are to be viewed, such as tailor's chalk marks on cloth, or where the boundary between two areas of a cloth sample having slightly different colors must be seen, the L-M meter used normally, with its wider field of view, will indicate a higher visibility level and give a lower recommended footcandle level than will the VTE. It is with tasks such as these that, because of the restricted field, relatively high footcandle recommendations may result from employing the Visual Task Evaluator.

The footcandles for equal visibility given on line "A" of Fig. 5 were obtained monocularly with the L-M meter restricted to a two-degree field, in order to make viewing conditions similar to those of the Visual Task Evaluator. Another set of readings was taken with the L-M meter used normally, with a ten-degree binocular field. For some of the tasks shown, there was little difference in visibility with the two viewing conditions, but with most of them the visibility was significantly higher with the ten-degree binocular field than with the two-degree monocular field. For instance, for a stain mark on fabric, both the Visual Task Evaluator and the L-M meter readings with the two-degree field indicated over 10,000 footcandles. The indicated footcandles with the L-M meter was reduced to approximately 100 footcandles when the ten-degree binocular field was used. A chalk line on cloth when viewed monocularly with the two-degree field required five times the footcandles as when viewed with the normal binocular field of the L-M meter. Even the indicated footcandles for reading type was 25 per cent higher with the restricted monocular field than with the normal L-M meter.

Another source of differences which may be encountered is the use of the average brightness of the task within the two-degree field as an essential part of the measuring technique with the VTE. It presents a problem which is recognized by those familiar with the Visual Task Evaluator, but so far it has not been possible to do more than recognize the problem.

In most cases the effect of "average brightness" is not serious, but it is quite possible to obtain widely different results, depending upon the reflectance of the area immediately surrounding the detail to be measured. For instance, a small detail on a white background one degree in diameter will have the same actual visibility whether or not the rest of the surround field is light or dark. Because of the lower average reflectance of the entire field, the task surrounded by the dark area will be assigned a higher footcandle value than the task surrounded entirely by a light field.

TABLE II — Footcandle Requirements for Four Tasks as Influenced by "Average Reflectance."

Task No.	Field Factor	APS	Brightness Required Foot-lamberts	Average Reflectance	Foot-candles Required
14	15	5	3.9	.59	6.6
27	15	5	9.0	.91	9.9
22	15	5	6.9	.33	21.
2	15	5	48.	.76	63.
14	15	1	1.3	.59	2.2
27	15	1	2.1	.91	2.3
22	15	1	1.8	.33	5.4
2	15	1	4.6	.76	6.1
14	10	1	.59	.59	1.0
27	10	1	.89	.91	.98
22	10	1	.78	.33	2.4
2	10	1	1.6	.76	2.1
14	5	1	.22	.59	.37
27	5	1	.30	.91	.33
22	5	1	.27	.33	.82
2	5	1	.45	.76	.59

An example of what can happen by using the average brightness of the task is shown in Table II, in which are given the footcandle requirements for four tasks with different Field Factors and APS values. Note that while the brightness requirements remain in the same order, several of the footcandle values indicate definite reversals as the Field Factor is reduced.

It is also possible for differences in surround brightness to have an adverse influence on the readings taken with the L-M meter. Diffusion in the photographic wedges will produce a veiling brightness from bright areas in front of the meter. In the case of the task being surrounded by a light area illuminated by a relatively high footcandle level, a veiling brightness could be produced which would cause the visibility reading to be lower than it should be. Thus, a higher footcandle level would be indicated for the task with the light surround than for the task with the dark surround. Of course, precautions should always be taken to shield the L-M meter properly when using it.[8]

These examples have been given to illustrate the possible causes of differences between the recommended footcandles from the Blackwell studies and those from the use of the L-M meter. It should be noted that those tasks whose visibility level is most affected by the limited field of view, and whose reflectances are low, such as stitching and marks on fabrics, may be assigned extremely high footcandle levels with the Visual Task Evaluator.

In spite of the differences encountered by using either the VTE or L-M meter, valuable data have been obtained with both instruments. The limitations of both instruments must be recognized when evaluating data taken with them. The use of per-

formance data in connection with the VTE readings is, of course, a great step forward toward the development of a method for determining optimal levels of illumination for various tasks.

While results with the L-M meter do not always agree with those of the VTE, it is possible in many instances to determine the reason for the differences. In most cases it is possible to obtain the same footcandle levels with the Visual Task Evaluator and the L-M meter by applying the Blackwell performance curves to data obtained with the latter. Thus, the L-M meter should continue to be a useful and practical portable instrument for evaluating visibility.

References

1. "New Footcandles Tables," ILLUMINATING ENGINEERING, Vol. LIII, No. 8, p. 425 (August 1958); "More Approved Illumination Levels," ILLUMINATING ENGINEERING, Vol. LIV, No. 2, p. 91 (February 1959).
2. *IES Lighting Handbook*, Third Edition, 1959.
3. "American Standard Practice for School Lighting," ILLUMINATING ENGINEERING, Vol. XLIII, No. 8, p. 793 (September 1948).
4. "Lighting for Machining of Small Metal Parts," ILLUMINATING ENGINEERING, Vol. XLIV, No. 10, p. 615 (October 1949).
5. "Recommended Practice for Residential Lighting," ILLUMINATING ENGINEERING, Vol. XLVIII, No. 8, p. 413 (August 1953).
6. "Recommended Practice for Office Lighting," ILLUMINATING ENGINEERING, Vol. LI, No. 6, p. 419 (June 1956).
7. Luckiesh, Matthew, and Moss, F. K.: "Visibility—Its Measurement and Significance in Seeing," *Journal of the Franklin Institute*, Vol. 220, p. 43 (1935).
8. Luckiesh, Matthew, Eastman, A. A., and Guth, S. K.: "Technique of Using the Luckiesh-Moss Visibility Meter," ILLUMINATING ENGINEERING, Vol. XLIII, p. 223 (March 1948).
9. Blackwell, H. Richard: "Development and Use of a Generalized Method for Specification of Interior Illumination Levels on the Basis of Performance Data," Proceedings of the 2nd Research Symposium of the Illuminating Engineering Research Institute, Dearborn, Mich., March 3-4, 1958.
10. Blackwell, H. Richard: "Development and Use of a Quantitative Method for Specification of Interior Lighting Levels on the Basis of Performance Data," ILLUMINATING ENGINEERING, Vol. LIV, No. 6, p. 317 (June 1959).
11. Luckiesh, Matthew, and Eastman, A. A.: "Footcandles for Critical Seeing," ILLUMINATING ENGINEERING, Vol. XLI, No. 10, p. 828 (December 1946).
12. Fry Glenn A.: "Comments Concerning the Use of the Luckiesh-Moss Visibility Meter for Prescribing Illumination," unpublished paper (1949).
13. Luckiesh, Matthew, Guth, S. K., and Eastman, A. A.: "A New Scale of Relative Footcandles for the Luckiesh-Moss Visibility Meter," ILLUMINATING ENGINEERING, Vol. XLV, No. 4 (April 1950).
14. "Report No. 1, I.E.S. Committee on Recommendations for Quantity and Quality of Illumination," ILLUMINATING ENGINEERING, Vol. LIII, No. 8, p. 422 (August 1958).
15. Dunbar, C.: "Fundamental Principles of Meters Used to Measure Visibility," *Transactions I.E.S. (London)*, Vol. 5, No. 3, p. 33 (March 1940).

DISCUSSION

H. RICHARD BLACKWELL:* The Luckiesh-Moss Visibility Meter has been used in the past to specify absolute or relative illumination levels for various tasks. It is naturally of very real value to relate the footcandle values obtained with this method with the values I have recently reported, which have become the basis of IES recommended practice. This the authors have done for 13 of the tasks we studied last year. The raw comparison shows some agreement in the ranking of various tasks but very substantial disagreement in the footcandle values, the range of values being much larger with my method than with the Luckiesh-Moss method. It has always been my contention that it is not possible to develop a means of converting from Luckiesh-Moss to Blackwell footcandle values and I am afraid the authors have not convinced me to the contrary. They make the optimistic statement that it should be possible to select a combination of Field Factor and APS values from my method to bring my values into agreement with those obtained with the Luckiesh-Moss system, but they do not substantiate this statement with fact and I am convinced it cannot be done. The mathematical bases of my method and the Luckiesh-Moss method are different in so many complex ways that it is to me inconceivable that conversion of footcandle values from one system to the other can be accomplished.

The authors may well agree with me on this point, in spite of their optimistic statements, because they devote most of their paper to a very different endeavor. They use the Luckiesh-Moss Visibility Meter to assess the values of $\bar{C}$, the contrast equivalents of the four-minute standard target, for various tasks and then enter these values into my performance data to obtain footcandle values. The footcandle values obtained in this way are compared with those obtained by using my Visual Task Evaluator and my performance data. Here there is much better agreement, as would be expected.

The agreement should be much better than it is, and presumably could be except for the roundabout method used by the authors to calibrate the Luckiesh-Moss Visibility Meter. The instrument should have been calibrated directly against four-minute standard targets of varying contrast. If this had been done, presumably the values of equivalent contrast obtained with the two instruments would have fallen on a line of 45-degree slope with zero intercept. Instead, the authors obtained a line with the wrong slope and with an intercept constant. This implies that footcandle values obtained by entering equivalent contrast values obtained with the Luckiesh-Moss Visibility Meter into my performance data cannot agree with values obtained with my VTE and performance data.

It is interesting to speculate about the relative merits of the Luckiesh-Moss Visibility Meter and the Visual Task Evaluator for use in determining values of equivalent contrast for various tasks. Used with my performance data, both instruments require that the performance data for various tasks are parallel to the performance data for the standard task on scales of log contrast versus log brightness, and displaced purely on the log contrast scale. It is my contention that the VTE is preferable in principle to the Luckiesh-Moss Visibility Meter because its use of contrast reduction minimizes the extent to which the performance curves must be parallel in comparison with the combined use of contrast and brightness reduction involved with the Luckiesh-Moss Meter.

The authors have shown that the field of view of a visibility meter affects the result obtained. This we have known. Our approach has been that there is no rational basis for selecting a field of view except for the IES assumption that the inner two-degree field constitutes the task background and the remainder of the field constitutes the surround. It is for this reason that we have selected a two-degree field.

In summary, the authors imply that they have found a way to convert footcandles obtained with the Luckiesh-Moss system to those obtained with my system. In my opinion, they have not been able to make such conversions. They have attempted to show that the Luckiesh-Moss Visibility Meter can be substituted for the Visual Task Evaluator in my system. To some extent this appears to be possible. A

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more satisfactory calibration method should have been used, however, and there remain real advantages in continuing to use the VTE.

GLENN A. FRY:* It is important to point out that the L-M Visibility Meter can be used to equate a given task to a four-minute circular test object, but it seems a much more direct method could have been used for calibrating the instrument for this purpose. It would suffice to use four-minute test objects (bright on a darker background) of various contrasts at a constant level of brightness, and measure the visibility levels. One could do this for different levels of luminance, but this is not necessary since it can be assumed on theoretical grounds that log contrast is a linear function of log luminance for levels of contrast higher than 30 per cent. From these data one can construct a graph like that in Fig. 3.

The indirectness has permitted systematic errors to distort the relations found in Fig. 2 from what one might expect on theoretical grounds. If four-minute test objects had been used one would expect Equation (1) to take on the form

$$y = x + a$$

where a is a constant. This means that the curves in Fig. 3 should have the same form and should be displaced in a vertical direction from each other.

A further simplification could be introduced by using the relative footcandle scale of the meter instead of the visibility scale, because the curves for different luminance levels on a plot of log contrast against log relative footcandles would be parallel straight lines.

A separate measurement of "average luminance" in the vicinity of the task is required.

The reason why the illumination requirements based on Blackwell's curve differ from those based on the level of visibility corresponding to 8 point Bodoni type at 30 footcandles merits further discussion.

The IES started out by specifying illumination standards in terms of visibility levels represented by curves on a log contrast-log luminance plot which are displaced laterally from the threshold curve. This procedure appeared to be justified because curves of constant relative performance based on Weston's data conformed to the curves representing visibility levels.

Blackwell on the other hand has argued with at least two kinds of evidence supporting him that suprathreshold levels of seeing must be represented by curves displaced upward from the threshold curve and his method of prescribing levels of illumination is based on this assumption.

Now where is the trouble? I think I have found it, because when we go back to Weston's data and use absolute rather than relative performance for defining suprathreshold levels of seeing, we find that these curves are displaced upward rather than laterally and this puts Weston's data into complete conformity with the Blackwell method.

Incidentally, this is a tribute to Professor Blackwell, Professor Strong and Mr. Crouch, who spearheaded the Blackwell approach. I was on the other side of the argument.

L. V. JAMES:** All measuring devices are essentially comparators, in one or both of two ways. Thus a yardstick may be used to determine the dimensions of an office in terms of a specific and accepted standard unit of distance and space. Or it may be used to learn whether the office is 15 feet square or 17 feet square (a marked difference of some 30 per cent). My experience with the Luckiesh-Moss Visibility Meter has been of the second order—as a field instrument—and this discussion is submitted to add to the comments of others along this line.

Soon after the meter was first introduced, it was demonstrated in Chicago one morning in an east-exposure office, where a statement was made as to the increase in footcandles needed on a calendar on a south wall to make it equally as visible as a different calendar on the north wall which received more of the light from the southeastern sky. Upon being challenged to state just how much increase was needed, the meter was used and the specific value given.

Immediately, one of those in the room measured the footcandles on the south wall calendar, with the daylight only and with that plus the electric lighting available, finding the increase in the second case to be almost exactly the amount previously stated as needed for equality of visibility. He then challenged the meter to show equal visibility with the north wall calendar with daylight only.

It was with considerable trepidation that this was attempted. I was the demonstrator and realized that the original adjustment of the meter must be good—it would be made while I still could not see the scale. And it was with equal relief that the readings proved the claim to be correct, the visibilities being found to be the same. It should be noted that no one in the room was then experienced in the use of the meter.

In the field, I never had occasion to try to justify the basic standard for the meter scale—it was felt that it would have been just as easy or perhaps easier to justify the recommended footcandles as to justify a standard to a layman. But the meter was used many times for comparison purposes; for instance, to show that the operator of a lathe needed much more light than he had on his work if its visibility were to equal that of the correspondence on the manager's desk. In fact, in one such case it was found necessary to put the correspondence on the floor under the desk to equate its visibility to that of the task on the lathe, under the illumination normally provided in each place.

The efforts of our Eastmans, Guths and Blackwells to establish precise standards are certainly to be applauded and encouraged, although the very nature of the field conditions make any such determinations indicative at best. But there also is a great need for simple, comparator devices which permit many of these field conditions to apply while the comparisons are being made. As such a device, the Luckiesh-Moss Visibility Meter has been found most useful.

DOMINA EBERLE SPENCER:* The work done by Eastman and Guth in correlating readings obtained with Blackwell's Visual Task Evaluator and with the Luckiesh-Moss Visibility Meter is valuable and has been well performed.

The value of either instrument in practical illuminating engineering is, however, somewhat questionable. With the Visual Task Evaluator, one may obtain a great deal of information on how well one can see various tasks when the visual field is artificially restricted to a two-degree, monocular peephole. But we very seldom are asked to work under such conditions. Both the elimination of the surround from the field of view and the artificial restriction to a monocular foveal field will have important effects on recommendations of quantity of light.

Current work by the CIE Colorimetry Committee indicates a significant difference between the trichromatic curves

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obtained with 2-degree and 10-degree fields and also suggests the strong probability that the effect of adaptation must also be included in accurate color discrimination work. Similar results are to be expected with the visual tasks of illuminating engineering. The effect of varying the field of view from 2 degrees to 10 degrees binocular is effectively demonstrated by Eastman and Guth, who give an example in which one hundred times as much light is required with the restricted field.

As normally used with a 10-degree binocular field, viewing conditions for the Visibility Meter are less abnormal than with the Visual Task Evaluator. But here too the surrounding field is not included in the field of view. Thus, the effect of the surround on ability to see detail in the 10-degree field cannot possibly be included.

Measurements made in a visual field that is artificially restricted tell nothing about what could be seen in an actual luminous environment. The attempt to oversimplify the specification of lighting by giving only the "footcandles recommended" for a given visual task is unjustified. What is needed is information on how well various visual tasks can be seen in actual non-uniform luminous environments including the effect of both direct and reflected glare.

Extensive use of the "footcandle recommendations" derived from either instrument is unwise. It raises the question as to whether illuminating engineering as practiced by the IES has a sound scientific basis. It is also a positive deterrent to the development and sale of high quality lighting equipment. For if a lighting system is rated only on how well one can see details through a peephole, the actual visual advantages of a well-designed, high quality surround will be entirely ignored. Until we can include the effect of the entire luminous environment we do not have an instrument which is visually significant.

CHARLES H. REX:* We welcome the work which has been done by the authors in correlating Luckiesh-Moss Visibility Meter ratings with those obtained using the Visual Task Evaluator.

Such studies should be extended to include roadway lighting conditions. It is hoped that the requisite level of relative visibility which evolves from Dr. Blackwell's studies can be correlated with the scale of the Luckiesh-Moss Meter which is relative to threshold or bare discernment.

We wonder if the gradient in the Luckiesh-Moss Visibility Meter should be replaced by the one developed by Professor Finch for his own meter and used in the Visual Task Evaluator. Shouldn't this eliminate the diffusion for which the Luckiesh-Moss Meter is occasionally criticized? The correlation of background data may be worth while to provide an improved version of the Luckiesh-Moss Meter.

A. A. EASTMAN AND S. K. GUTH:** Dr. Blackwell raises some very important and interesting points in support of his Visual Task Evaluator method for determining lighting levels for various tasks. It is true, as he points out, that there are many complex differences between the two *complete* methods for determining footcandle levels. However, by separating the instrumental or measurement part of the method from the specification portion, it may be possible to determine some of the causes for these differences.

Fundamentally, with the VTE the visibility of a task or object is equated to a specific contrast of the standard four-minute luminous target. On the other hand, the original calibration of the Luckiesh-Moss Visibility Meter provides an equivalency in terms of the size of a high contrast parallel bar test object. Such a reference scale has been found useful and readily understandable.

However, as we mentioned in the "Conversion Procedure" section of our paper, we have available detailed information which gives the relationships between contrast and brightness for parallel bar test objects, as well as information relating the recognition of detail of the parallel bar test object to the recognition of presence of a disc.[7,8,11]*

These relationships, modified by the experimentally determined relationships shown in Fig. 2, form the basis for the determination of the conversion curves in Fig. 3. They are based on experimental data, and are just as valid as though determined by direct calibration. Dr. Fry states that "the indirectness has permitted systematic errors to distort the relations found in Fig. 2 from what one might expect on theoretical grounds." Dr. Fry also suggests that the systematic errors, having distorted the relationships shown in Fig. 2 would, in turn, influence the displacement and parallelism of the curves of Fig. 3. With the exception of that for one footcandle (which is not far off), all the curves of Fig. 3 are of the same form and are displaced vertically from each other.

As we have pointed out, if the two instruments were identical in operating characteristics, it would not be necessary to determine the relationship shown in Fig. 2; it would show a 45-degree slope without a constant.

It is well-known that there is a slight amount of diffusion in the L-M variable density wedge and that it does not bear a constant relationship to the density. In fact, while the density changes over a wide range, the diffusion changes only a very little. The diffusion component is probably an important reason for differences between contrast evaluations obtained with the two instruments. According to Dunbar's[15] analysis of various types of wedges which could be used in visibility meters, Fig. 2 is not distorted but does seem to confirm what should be expected on theoretical grounds. This has been partially substantiated by limited data obtained with an experimental variable density wedge having no diffusion.

Regarding the specification of levels of illumination, the data obtained with each instrument are used in conjunction with appropriate brightness—or footcandle—relationships. As we have shown, footcandles for equal visibility (L-M) can be converted into footcandles for equal visual performance (VTE). Obviously, the converse can be done.

The principal difference between footcandles for equal visibility as determined with the L-M meter and footcandles for equal performance as determined by Blackwell is, of course, in the application of "specification curves" to the basic data as determined with the VTE. The application of a specification curve to basic data accounts for the wide range in footcandle values between "easy" and "difficult" tasks as compared with the range of values for the same tasks obtained with the application of the relative footcandle scale to the L-M meter values. This range is narrowed or widened according to the choice of specification curves.

It is assumed that the curves relating contrast and brightness for various Field Factors and APS values would be parallel, regardless of the criterion used in their determination, but it has not been shown that it is, in fact, true. The curves are very flat in the high brightness range so that a slight change in slope would produce a great change in specified brightness. The basic curves, before application

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of Field Factors and APS values, were obtained entirely with the recognition of the presence of a luminous disc as a criterion. The question naturally arises as to what would happen if they were based on the recognition of detail rather than presence.

In his investigation with the Visual Task Simulator, Blackwell has shown what seems to be an indication that the experimental curves are not parallel to the threshold curves. Also, there seems to be a tendency toward less flattening of the curves at higher brightness levels, especially when the target is a cross. It is obvious that if Blackwell's "specification curves" significantly depart in this manner from being parallel to his threshold curves, the indicated levels of illumination for many of the tasks will be considerably lower than the published values. If this would be the case, the relative footcandle levels for the various tasks would be more nearly the same for an appropriate combination of FF and APS and a specific visibility level.

The matter of the field of view of such instruments is, we think, important. Furthermore, we are not aware of "the IES assumption that the inner two-degree field constitutes the task background and the remainder of the field constitutes the surround." This limitation was accepted as one of the characteristics of the Visual Task Evaluator. It certainly seems unreasonable to assume that the visibility of a task, part of which lies outside the two-degree field, will be accurately evaluated by any instrument whose field of view is limited to two degrees. For example, a long thin line is considerably more visible than a two-degree segment of it.

The purpose of our paper was not to prove one instrument better than the other. We do not intend to depreeate the use of the Blackwell Visual Task Evaluator. We have shown that data obtained with the two instruments can be related and that there are explainable reasons for many of the differences. We are confident that Dr. Blackwell recognizes some of the problems and ultimately will have answers to them.

As Mr. James has pointed out, the Luckiesh-Moss Visibility Meter has been used for many years for evaluating practical visual tasks at the point of work. Its portability is a definite advantage. When precise specification curves have been firmly established, evaluations can be made with any of several types of visibility meters for the purpose of determining levels of illumination.

We agree in part with Dr. Spencer's dicussion of the extensive use of the "footcandle recommendations" derived from either instrument. The entire luminous environment should be considered when applying "footcandle recommendations" and we believe most lighting engineers are aware of this. Certainly, in most of the recent literature pertaining to illumination, quality as well as quantity is stressed. "Footcandle recommendations" tell *how much*, but because neither instrument will give the "how" of good lighting there is no reason for failing to take advantage of the information obtained. It is far superior to merely guessing. No measuring technique has ever reached absolute accuracy and we still "pace off" distance when a more accurate method of measurement is not available. In spite of the shortcomings of each of the meters, they both have their place in the measurement of visibility.

Mr. Rex's question about the use of the Finch wedge in a portable instrument also has been asked by others. In order to accomplish the objective which the VTE fulfills—maintenance of constant average brightness in the field of view—the wedge requires an external source of illumination to provide a veiling brightness. This, as well as the relatively high cost of the wedge, makes it impractical as a substitute for the photographic wedge in a portable instrument such as the L-M meter.

High Level Office Lighting

Eight- by ten-foot panel suspended one foot from the ceiling and equipped with six 96-inch PG17 lamps produces 300 footcandles on the desk in this New York City executive office. Lamps are mounted directly above plastic panels in the lamp compartments, providing both uplight and downlight. Light reflected from the ceiling is diffused by panels of colored egg-crate louvers between the lamp compartments. Although the desk, at present, has a darker finish than meets IES recommended practice, all other surfaces, including the light-colored carpeting, provide brightness ratios which are compatible with good current practice. Photo and data courtesy of Silvray Lighting, Inc., Bound Brook, N.J.

A.I.A. File No. 31 f

INSTALLATION AT JOHN E. MEYER & SON, PHILADELPHIA, PA.

Lighting a Composing Room

LIGHTING OBJECTIVE: To provide comfortable diffuse illumination with a high downward brightness for portraying type in a composing room.

GENERAL INFORMATION: This composing room is approximately 28 feet by 48 feet, with a ceiling height of 12 feet. Colors and reflectances of the major room surfaces are:

ceiling	white	80% RF
walls	white	80% RF
dado	gray	28% RF
floor	concrete	37% RF
cabinets	light gray	37% RF
cabinets	dark gray	7% RF

INSTALLATION: Twenty Day-Brite Lighting, Inc. catalog No. 81257-8 industrial type fluorescent luminaires, with 25 per cent up-light and 30-degree crosswise and 20-degree endwise shielding, provided an average illumination level of 140 footcandles after 400 burning hours. The luminaires are mounted 9 feet above the floor in basically continuous rows, 6 feet on centers. Each luminaire is equipped with two 96-inch T-12 warm white high output rapid start lamps, providing the high downward brightness for good contrast between shoulder and type face (see Fig. 2).

(over)

A.I.A. File No. 31 f

Figure 2. Close-up showing type

The brightness straight down is in excess of 3000 footlamberts. Brightnesses of the room surfaces after 400 burning hours were:

ceiling	36 fL	floor	41 fL
walls	48 fL	cabinets	4-22 fL
dado	17 fL		

Lighting designed by James R. Rodisch, Philadelphia Electric Co., Philadelphia, Pa.

Lighting data submitted by James R. Rodisch and George T. Anderson, Jr., Philadelphia Electric Co., Philadelphia, Pa., as an illustration of good lighting practice and to aid in the design of similar installations.

Published by the Committee on Publications of the Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

Mercury Lamp with Internal Cutout for Trouble-Free Straight Series Circuits

By W. C. MATZ

This article presents the development of a new 400-watt mercury lamp designed specifically for straight series street lighting use. The new lamp is intended to eliminate the troublesome and expensive field problem of "false" film cutout failures. The significant feature is the addition of a simple internal cutout inside the lamp base. This cutout has a high breakdown voltage and, unlike previously used film cutouts, will withstand severe line transients. It operates to protect the socket and circuit continuity only when the lamp arc tube is no longer operative.

THREE TYPES of mercury lamp street lighting systems are presently in popular use. These are the individually-ballasted systems with parallel-connected (multiple) primaries, the individually-ballasted with series-connected primaries, and the straight series (ballastless) with a constant-current transformer and series-connected lamps. This paper discusses the last, some of its advantages and disadvantages, and a new mercury lamp, the H1BA, designed especially to improve ballastless systems.

Briefly, a straight series system[1,2,3,4] consists of a constant-current transformer with an open-circuit voltage high enough to start 25 to 35 mercury lamps connected in series, and with a constant-current output set at the nominal lamp current. For the 400-watt lamp, this current is 3.2 amperes. To keep the circuit operating in case of a lamp failure, past practice has been to place a film cutout in parallel with each lamp. This use of film cutouts and the circuit in general were borrowed from series filament lamp systems. If a lamp failed to operate, the cutout would break down as a result of the high voltage building up across the socket; this breakdown resulted in a short-circuit which completed a path around the defective lamp. The system also includes protective relaying to guard against line dips, hot restarts, and open circuits.

Straight series systems have advantages of lower initial equipment and installation costs, lower power consumption, and smaller and more closely regulated power supplies. The disadvantages are the necessity for providing cable and socket insulation for the high voltages involved, the precautions necessary for servicing, and false film cutout failures. The reliability of some systems has been increased by providing positive protection from "hot restarts"—conditions in which, after brief power outage or de-energization of the circuit, energy is again applied to lamps that are hot and will not start normally. This prevents prolonged application of high voltage across hot lamps and insures that the power is off whenever the lamps are not operating, a very desirable safety feature. Older circuits depended upon matching a voltage-sensitive relay in the primary with the dropout characteristics of the lamps. The difficult matching problem has been eliminated by controlling the protective relay with lamp current instead of primary voltage.[5] In this way, the protective relay is made to operate every time that lamp current stops while the main switch is on.

AUTHOR: Discharge Lamp Engineering, General Electric Co., Cleveland, Ohio.

False Film Cutout Failures

The film cutout is a sandwich of insulating and conducting discs which is non-conducting below a critical voltage, but which breaks down above that voltage and permanently conducts. Breakdown should normally occur only when lamps fail.

Serious troubles, called false cutout failures, were experienced in the use of these systems. These occurred when one cutout, several cutouts, or all cutouts in a circuit failed without any lamp misfunction. Such failures require a servicing trip and cause much trouble and expense for the user.

The exact circumstances surrounding the failures were hard to determine, but the occurrence of line fluctuations, starting transients, transients induced by lightning strokes, and cold weather starting were all blamed for false cutout failures.

Improvements were made in the cutouts, and

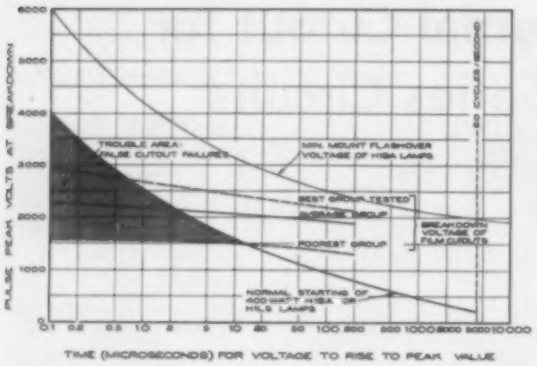

PULSE PEAK VOLTS AT BREAKDOWN
TIME (MICROSECONDS) FOR VOLTAGE TO RISE TO PEAK VALUE
60 CYCLES/SECOND
TROUBLE AREA: FALSE CUTOUT FAILURES
MIN. MOUNT FLASHOVER VOLTAGE OF H33A LAMPS
BEST GROUP TESTED
AVERAGE GROUP
POOREST GROUP
BREAKDOWN VOLTAGE OF FILM CUTOUTS
NORMAL STARTING OF 400 WATT H33A OR H1L5 LAMPS

Figure 1. Breakdown voltage vs. rise time for film cutouts and normal 400-watt mercury lamp arc tubes.

100 per cent inspection was initiated, but the trouble continued. Some design changes were made in lamps and field tested, also with little avail.

Pulse Breakdown Tests

It was obvious that false cutout failures were being caused by transients which punctured or broke down cutouts before perfectly normal lamps could start. Laboratory tests at 60 cycles with controlled line fluctuations on the primary of a complete straight series system did not produce cutout failures, or show differences between lamps of different manufacturers. This led to the thought that transients of very short duration were causing trouble.

Tests were made on lamps and film cutouts using high-voltage pulse-testing equipment in which the rate of rise and peak voltage of a repeating pulse could be varied to obtain a curve of breakdown voltage versus rise time.[6] Fig. 1 illustrates the data obtained. The relatively flat curves show how the breakdown voltage of film cutouts, representative of three manufacturers, varies with rise time. The lower curve sloping up to the left shows how the breakdown voltage of a normal 400-watt arc tube varies with rise time during normal starting. This curve is similar to those obtained for old and new lamps and for lamps of more than one manufacturer. Fig. 1 shows that, for rise times less than ten microseconds, it is possible for a film cutout to break down before a normal lamp can start. The shaded area indicates the troublesome region where false cutout failures can occur.

Arcing Fuse or Internal Cutout

At the time when false cutout failures were under investigation, another problem appeared. There were occasions when, because of a hot restart or a defective arc tube, an arc would strike between parts of the mercury lamp mount. The arc would then progress into the base and socket, destroying both, until the arc was quenched by fusion of the molten parts. The use of a shorting or arcing fuse was suggested. The idea was to wrap one lamp lead around the other with the two separated by a glass sleeve slipped over the latter. The progress of the arc would melt the insulator between leads, allowing them to fuse and short-circuit, protecting the socket and maintaining circuit continuity.

It was thought, too, that such a fuse could function as a cutout, whereby, in case of lamp failures, the high voltage impressed across the lamp would cause lamp mount flashover, arcing, and then fuse short-circuiting. It was found that a certain glass composition was necessary for the sleeve, and that the encircling wire must have a certain minimum size, depending upon the lamp current and other conditions.[7]

Two types of fuses were tried. One, a modification of the original idea, was an effort to get faster action and minimize stem damage. These fuses were made by slipping a short piece of glass tubing over one of the short parallel stem leads emerging from the lamp stem press (see Fig. 2a) and encircling it with a wire loop welded to the opposite lead. Laboratory and field tests showed, however, that the breakdown voltage was too low between the wire loop and the lead in lamps having normal jacket filling pressures. There were occasions of fuse breakdown in lamps with good arc tubes.

The other type of internal cutout tried, the one being used in the new lamp, is shown in Fig. 2b. It is located within the base where its breakdown voltage is high enough to be unaffected by transients. With the introduction and use of the internal cutout, a new mount was designed and the bulb changed from soft to hard glass. The mount structure was changed, and the heat disc removed to obtain maximum spacing and provide a lamp that would withstand a high transient voltage

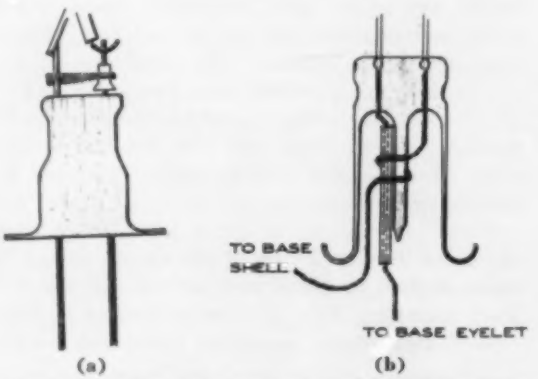
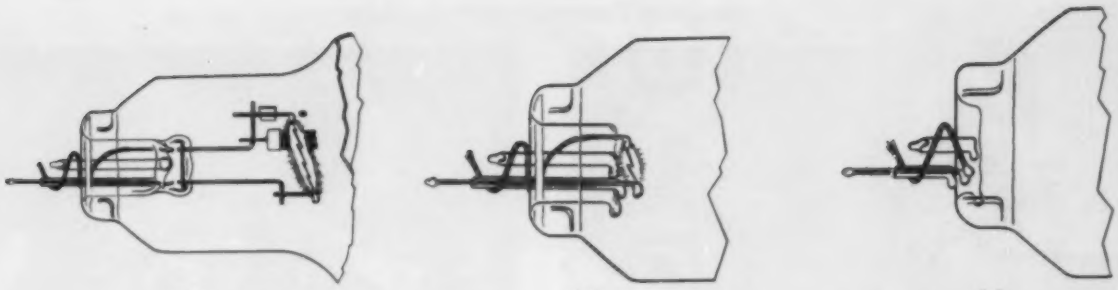


Figure 2. (a) Internal cutout on stem inside lamp outer bulb; (b) internal cutout within base and stem.



(a) (b) (c)

Figure 3. How the internal cutout works. One of the lead-in wires is enclosed in a special glass sleeve; the other wire is wrapped around this sleeve. When the lamp has burned out (a) an arc forms between the lead-in wires, (b) the arc travels into the glass sleeve and melts it, (c) the special sleeve enables the lead-in wires to fuse together, completing the circuit and extinguishing the arc before it reaches the socket.

without flashing over. Elimination of the heat disc limits the burning position to the range from horizontal to base-down, because a heat disc is necessary to prevent excessive socket temperatures in base-up burning. Since all modern street lighting installations employ near-horizontal burning, this burning position limitation is acceptable. The new lamp in a clear bulb is designated the H1BA (according to the ASA system of industry-wide mercury lamp designations). Slightly different ordering abbreviations are used for the phosphor-coated lamps. The upper dotted line in Fig. 1 shows the minimum flashover voltage for the mount and internal cutout and indicates how high a transient the lamp will take without damage. The mount and internal cutout flashover voltage is approximately 2000 volts higher than that required to strike an arc within a normal lamp arc tube. The mount will flash over and the internal cutout will function as shown in Fig. 3 when the lamp has reached end-of-life, but not before.

In the rare instance when the lamp jacket leaks to the atmosphere before arc tube failure, the lamp flashover voltage increases. To avoid arcing at the socket, the lampholder assembly should be able to withstand 5000 volts rms. If the fixture formerly used a cutout holder, it too must be insulated for this voltage. Although high, this voltage cannot be lowered without reducing the lamp flashover voltage and making it more susceptible to transients. We have been able to meet this specification by modifying some existing sockets. The socket manufacturers contacted have stated that they can meet the required breakdown voltage without major design changes.

Tests of the Internal Cutout

In addition to laboratory tests of the internal cutout, H1BA lamps have been operated for more than 8000 hours without trouble on a complete straight series system installed for test purposes on one of our buildings. Field tests have been in progress in one installation since October, 1957, and another since May, 1958, with satisfactory performance and no reported instance of false failures to date. The lamp was made commercially available in August, 1958.

Summary

This paper has described a new lamp designed for straight series circuits to overcome the problem of false cutout failures which occurred in previous systems. Laboratory tests have shown that some line transients can break down and permanently short-circuit film cutouts before a mercury lamp can start. A new, internal cutout that can withstand these transients has been built into a lamp, and the mount flashover voltage increased. The tests and field performance of the H1BA mercury lamp with its internal cutout show it to be far superior to film cutouts in resisting breakdown caused by transients. Its use should markedly increase the economy and attractiveness of straight series systems by eliminating the necessity for frequent fixture servicing trips.

Acknowledgments

I wish to acknowledge the assistance and contributions of H. A. Breeding, Outdoor Lighting Department, General Electric Co.; my associate, E. C. Martt; and P. N. Bosworth of the General Engineering Laboratory, General Electric Co.

References

1. McIntyre, H. N.: "Operation of Mercury Vapor Street Lighting Lamps," *Distribution* (January 1951).
2. Standley, S.: "Uni-Ballast System in Street Lighting," a paper presented at IES Regional Conference, Denver, Colo., April 15, 1954.
3. Keck, M. E. and Oglesbee, W. A.: "Operation of Mercury Vapor Lamps on Series Street Lighting Circuits," ILLUMINATING ENGINEERING, Vol. L, No. 3, pp. 115-122 (March 1955).
4. Scholz, C. F., Keck, M. E. and Oglesbee, W. A.: "Operation of Mercury Vapor Lamps on Series Street Lighting Circuits—Part II," ILLUMINATING ENGINEERING, Vol. L, No. 12, pp. 579-584 (December 1955).
5. U. S. Patent No. 2,838,717, Breeding, H. A. and Martt, E. C.
6. Rohats, N.: "A New Instrument for Analyzing Electric Transients," General Electric Review (February 1942). This article describes equipment similar to that used in pulse breakdown tests.
7. Patent applied for—Breeding, H. A. and Martt, E. C.

Joint meeting of Michigan Section and Residence Lighting Forum at Detroit Boat Club featured Clifford Wright, AIA (left in photo at left), speaking on "New Ideas in Future Home Lighting." Mr. Wright is shown here with Section Chairman, Edmund Pratt. Manning the slide projector, photo at right—Mary Taepke, John Miller.

About 30 members of School, Office and RQQ committees met at Ohio State University, December 8-9, to consider the status of research pertaining to problems facing the committees. H. R. Blackwell, B. S. Pritchard, H. F. Davidson, Phelps Meaker and C. L. Crouch presented reports on direct and flected glare studies which resulted in reaffirmation of "scissors curve" for judging acceptability of luminaires from viewpoint of average brightness at various angles. New information on loss of contrast due to reflections, development of a method of assessing these losses and possible gains to be obtained through varying forms of light distribution was also presented.

Charter presentation to newly organized Residence Lighting Forum, sponsored by Coastal Bend Chapter (Corpus Christi, Texas), is made by L. H. Kindel (right in photo at left), Coastal Bend Chapter Chairman, to Jack Rice Turner, Chairman of the new Forum. Officers of Forum in photo at right are, left to right: Mr. Turner; Mrs. Ralph Holeman, Secretary-Treasurer; Mrs. Virginia Benson, Chapter Forum Committee Chairman; Glenn Price and Mrs. Freddie Hayslip, Executive Committee Members-at-Large. Missing from photo is Mrs. L. A. Schuette, Vice Chairman. Coastal Bend Forum, the fourteenth to be organized, is the first to be sponsored by a Chapter.

LIGHTING NEWS

Office Lighting Practices Symposium Presented by New York Section

In New York City alone, some 43 office buildings are currently in various stages of construction. Their details, of course, are of great interest to architects, consulting engineers, lighting men and office managers.

To bring before these men some of the problems and/or solutions, particularly those relating to the lighting, the New York Section of IES presented an all-day Symposium on Office Lighting on January 28. The meeting was held at Consolidated Edison's auditorium in New York, beginning at 2:00 p.m., continuing through dinner there, to 8:30. Some 186 people attended.

Notebooks must surely be filled with the pertinent office lighting information which developed from this conference. First speaker was H. MacNary, Vice President of Fischbach & Moore, contractors, who outlined "Code Requirements, Past, Present and Future." As to the future, he noted that energy consumption in office buildings has advanced at a rate which has doubled each 10 years; capacity has tripled every quarter century; that many older skyscrapers have had to reconstruct for greater capacity as often as three times in the past 25 years. The logistics now concerned with lighting in office buildings was an interesting problem also outlined by Mr. MacNary. With current levels especially, he noted the new problem of receiving and distributing vast numbers of lighting fixtures, some 30,000 in a single installation, for example. Their solution: fixtures delivered in skids, 36 to a skid, on Saturdays. This has permitted the handling of 3800 fixtures in one eight-hour day with a minimum of personnel.

Richard Kelly, well-known New York lighting consultant, was the second speaker. His subject: "Creative and Artistic Applications of Light to Entrance Facades, Lobbies and Special Offices." Design in office buildings, he noted, starts with the owners' concepts for the top executive offices, which sets the pace for the secondary offices, which in turn influences the concept for the clerical areas—all of which stresses the fact that the lighting must be planned first, and coordinated from the start, in the architect's plans.

Len Parks, Supervising Electrical Engineer for Ebasco Services Inc., discussed "Quality in Coordinated Lighting." His

PRINCIPALS in New York Section's symposium on office lighting, left to right in photo at left: E. Kassman, symposium chairman; Harry MacNary, Fishback & Moore, Inc.; Len Parks, Ebasco Services, Inc.; William H. Keen, New York Section Chairman. In photo at right: R. K. Posey, Skidmore, Owings & Merrill; A. Windman, Syska & Hennessy. Others participating in the symposium but not shown here were B. F. Winckowski and R. S. Lundberg, Voorhees, Walker, Smith, Smith & Haines and New York City lighting consultant, Richard Kelly.

premise: Anybody can design for the required footcandles. Quality needs a three-man team of lighting engineer, architect and interior designer.

A two-man team from Voorhees, Walker, Smith & Haines described the coordinated lighting of the Proctor & Gamble Building in Cincinnati. These were B. F. Winckowski, chief of the electrical division, and R. S. Lundberg, an associate of the company.

Lighting coordinated with the decor and architecture of the new Union Carbide Building in New York was discussed by A. Windman of Syska & Hennessy, and R. K. Posey, of Skidmore Owings and Merrill. This is a floor-to-ceiling glass building which at night is a new tower of light on the New York sky line. The specific lighting problem for this effect was covered in detail by both men. Of interest also were: multiple-function ceiling, lighting design for frequent repartitioning, and the early stage planning of the lighting design, including several life-sized mockups of offices to study both daylight and electric lighting systems.

The Symposium concluded with a half-hour session of written questions to each speaker.

Following the meeting, groups were guided by Consolidated Edison personnel through several private offices of the utility which have been designed for 450 footcandles.

Chairman for the Symposium was E. Kassman, Westinghouse Electric Corp., New York.

Direct Energy Conversion Study Sponsored by EEI

A research project on methods of converting various forms of energy directly into electricity has been initiated by the Edison Electric Institute. Objective of the study, scheduled to take about a year, is the evaluation of the potential of each direct conversion method for the bulk production of electricity. Results of the project are expected to provide a basis for future action by the EEI in this field.

Theodore Baumeister, Steven Professor of Mechanical Engineering at Columbia University and consulting engineer, heads the project, working under the direction of an EEI Steering Committee, J. G. Miller, Metropolitan Edison Co., Chairman. Results of the research are expected to be available to the sponsoring groups by mid-1960.

In direct conversion, electricity is generated directly from raw energy such as heat, chemical and nuclear sources without the use of conventional equipment such as turbines and generators. Many of the principles of direct conversion have been understood for over a century, but until recently there were no indications that this method had promise for significant advances in the efficient generation of power for public utility use. As a result of important developments in the past several months, the EEI technical committees decided to undertake a comprehensive survey of the status and potential of this unconventional power source. Professor Baumeister will consider the many direct conversion concepts and devices in the course of his research.

Organizations interested in research and development in the direct energy conversion field are invited to submit information, for inclusion in the study, to: Steering Committee, EEI Direct Energy Conversion Research Project, Edison Electric Institute, 750 Third Avenue, New York 17.

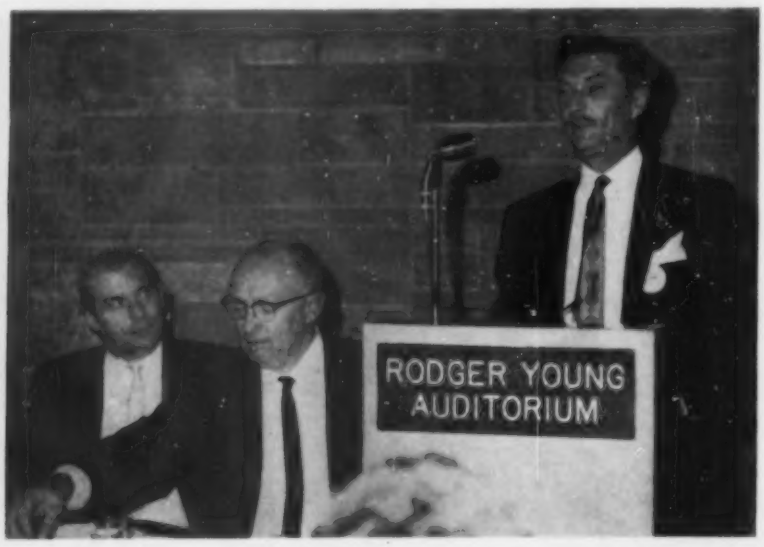
Office Conference Rescheduled To Coincide with '64 World's Fair

The National Office Management Association's International Conference of Office Administrative Executives, originally planned for New York City in 1961, has been rescheduled for New York in 1964. Reason for the change, according to the National Office Management Association and the Office Executives Association, host Chapter for the Conference, is the World's Fair set for New York in 1964, which will offer an additional attraction for the conference delegates.

The 1961 NOMA 42nd International Conference and Office Equipment Exposition will be held in St. Louis, Mo., May 7-10. Conference headquarters will be the Sheraton-Jefferson Hotel, with the exposition to take place in the Kiel Auditorium.

NOMA's 1960 Conference is being held May 22-26, in Montreal, Canada at the

(Continued on page 11A)



PANEL discussion on light control provided provocative evening for 125 IES'ers in Southern California. Speakers included Alexander Jung, Rohm & Haas (photo at left), discussing light control with plastics; Louis Erhardt, Century Lighting (at microphone in photo at right), on reflectors and reflector design; Paul Davis, Corning Glass Works (left, photo at right), speaking on light control with glass. Program was arranged by J. S. Hamel (in center in photo at right), Southern California Section program chairman.

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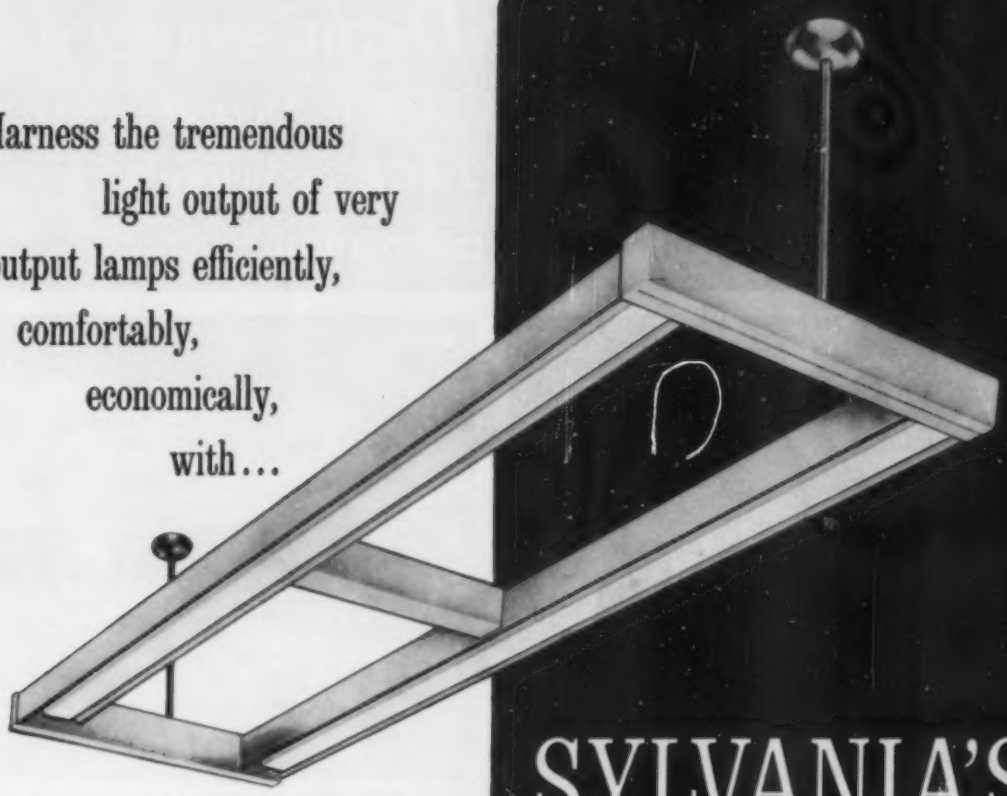
high output lamps efficiently,
comfortably,
economically,
with...



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WELL LIGHTED-THE SECOND TIME!

The famous LOCHMOOR CLUB of Detroit now uses the same *TOTAL WATTAGE* as before to get *TWICE* as much light

DOWN LIGHT—TOO CONCENTRATED

Low-brightness on the *object* you are looking at
No brightness on the *vertical* surfaces

KIRLIN—WIDE SPREAD—GLARE-FREE

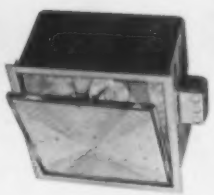
All objects to be seen are well lighted
Wide distribution lights the vertical surfaces

No "Hot Spot" with Kirlin Lenses

LAFAYETTE (IND.) SUPER MARKET

Down lights are intended for spot lighting not for area lighting—Bascart in foreground is hardly distinguishable

Kirlin SYSTEM
BUILT-IN *Lighting*



FORT LAUDERDALE AIRPORT

Kirlin wide angle lenses light both vertical *and* horizontal surfaces.
Note how car in background stands out

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(*Continued from page 8A*)

Queen Elizabeth Hotel. Twelve forums, limited to 50 registrants each, have been scheduled around the conference theme "New Dimensions for Office Executives." The equipment exposition to be held in conjunction with this conference will be at Montreal's Show-Mart.

Miami Beach Chosen for 1964 IES Conference

On the recommendation of the National Technical Conference Committee, C. L. Amick, Chairman, Council voted to accept the invitation of the Southeast Florida Section to hold the 1964 IES National Technical Conference in Miami Beach, Florida. The Conferenee will be held August 30 through September 3, 1964 at Miami's Fountainbleau Hotel.

With the approval of these Conference plans, dates and locations for the next five Conferences are:

1960—September 11-16—Penn Sheraton Hotel, Pittsburgh, Pa.

1961—September 24-29 — Chase Park Plaza Hotel, St. Louis, Mo.

1962—September 9-14 — Statler-Hilton Hotel, Dallas, Texas.

1963—September 8-13—Sheraton Cadillac Hotel, Detroit, Mich.

1964—August 30-September 3 — Fountainbleau Hotel, Miami Beach, Fla.

Standardization Projects for Data Processing, Office Machines

Initial steps toward national and international standardization of office machines and data processing equipment (including digital computers) were taken as a result of a national conference held in New York in mid-January, under the sponsorship of the American Standards Association.

The conference was called by ASA to consider proposals by two international standards groups (International Standards Organization and International Electrotechnical Commission) for American participation in standardization projects already underway.

The conference gave its approval for American participation in the office machines project set up by ISO under the direction of the Italian standards organization and in an international roundtable to consider the desirability of international standards for digital computers and data processing equipment, under the IEC.

The international roundtable will discuss the feasibility of an international machine language by which data programmed for one computer could be used in other computers without recoding.

To prepare American Standards in

(*Continued on page 12A*)

SCHEDULED EVENTS

March 23-26, 1960—Tenth Electrical Industry Show and Lighting Exposition, Shrine Exposition Hall, Los Angeles, Calif.

March 29-31, 1960—American Power Conference, sponsored by American Institute of Electrical Engineers, American Society of Mechanical Engineers and Illinois Institute of Technology, Sherman Hotel, Chicago, Ill.

April 4-6, 1960—American Institute of Electrical Engineers, Southwest District Meeting, Houston, Texas.

April 5-7, 1960—Building Research Institute, Spring Conferences, Statler-Hilton Hotel, New York, N. Y.

April 7-8, 1960—Society of the Plastics Industry, Western Section Conference, Riviera Hotel, Palm Springs, Calif.

April 11-12, 1960—Inter-Society Color Council, Philadelphia Museum College of Art, Philadelphia, Pa.

April 12-14, 1960—American Institute of Electrical Engineers, East Central District Meeting, Charleston, W. Va.

April 20, 1960—Council Executive Committee Meeting, Illuminating Engineering Society, Memphis, Tenn.

April 21-22, 1960— South Central—Southeastern Regional Conference, IES, Hotel Peabody, Memphis, Tenn.

April 25-26, 1960—Southwestern Regional Conference, IES, Robert Driscoll Hotel, Corpus Christi, Texas.

April 27-29, 1960—American Institute of Electrical Engineers, Great Lakes District Meeting, Milwaukee, Wis.

April 28-29, 1960—Inter-Mountain Regional Conference, IES, Mountain Shadows Resort, Scottsdale, Ariz.

May 1-5, 1960 — Electrochemical Society, Spring Meeting, LaSalle Hotel, Chicago, Ill.

May 1-5, 1960—National Association of Electrical Distributors, Dallas, Texas.

May 2-4, 1960—American Institute of Electrical Engineers, Northeastern District Meeting, Providence, R. I.

May 3-5, 1960—South Pacific Coast Regional Conference, IES, Hollywood Roosevelt Hotel, Hollywood, Calif.

May 9-10, 1960—Pacific Northwest Regional Conference, IES, Benjamin Franklin Hotel, Seattle, Wash.

May 10-12, 1960—American Institute of Electrical Engineers (Farm Electrification Conference), Sheraton-Fontenell Hotel, Omaha, Nebr.

May 12-13, 1960—Midwestern Regional Conference, IES, Sheraton Martin Hotel, Sioux City, Ia.

May 12-14, 1960—American Institute of Industrial Engineers, Annual Meeting, Dallas-Sheraton Hotel, Dallas, Texas.

May 16-17, 1960—Great Lakes Regional Conference, IES, Hotel Carter, Cleveland, Ohio.

May 22-26, 1960—National Office Management Association, 41st International Conference and International Office Exposition, Queen Elizabeth Hotel and Show-Mart, Montreal, Que.

May 23-26, 1960—Design Engineering Show, Coliseum, New York, N. Y.

June, 1960—Society of Plastics Engineers, Vinyl Plastics Meeting, Boston, Mass.

June 6-8, 1960—Edison Electric Institute, Annual Convention, Atlantic City, N. J.

June 8-9, 1960—Northeastern Regional Conference, IES, Wentworth-by-the-Sea, Portsmouth, N. H.

June 8-11, 1960—National Society of Professional Engineers, Annual Meeting, Statler Hotel, Boston, Mass.

June 10-26, 1960—British Exhibition (Industry, Technology, Science, Culture), New York City Coliseum, New York, N. Y.

June 12-15, 1960—American Society of Heating, Refrigerating and Air Conditioning Engineers, Annual Meeting, Vancouver, B. C.

June 13-14, 1960—Canadian Regional Conference, IES, Nova Scotian Hotel, Halifax, N. S.

June 16, 1960—Council Meeting, Illuminating Engineering Society, New York, N. Y. Members are free to attend meetings of Council as guests.

June 19-24, 1960—American Institute of Electrical Engineers, Summer General Meeting, Atlantic City, N. J.

June 20-24, 1960—American Society for Engineering Education, Annual Meeting, Purdue University, Lafayette, Ind.

August 8-12, 1960—American Institute of Electrical Engineers, Pacific General Meeting, El Cortez Hotel, San Diego, Calif.

September 6-16, 1960—Production Engineering Show, Navy Pier, Chicago, Ill.

September 10-18, 1960—Electrical Living Show, New York Coliseum, New York, N. Y.

September 11-16, 1960—Illuminating Engineering Society, National Technical Conference, Penn-Sheraton Hotel, Pittsburgh, Pa.

September 28-30, 1960—Canadian Electrical Manufacturers Association, Sheraton-Brock Hotel, Niagara Falls, Ont.

October, 1960—American Society for Engineering Education, Annual Meeting of North-Midwest Section, Marquette University, Milwaukee, Wis.

October 9-14, 1960—American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

October 13-15, 1960—Optical Society of America Meeting, Somerset Hotel, Boston, Mass.

October 15-20, 1960—American Institute of Electrical Engineers, Fall General Meeting, Detroit, Mich.

October 19, 1960—Society of Plastics Engineers, Tooling for the Plastics Industry, New York, N. Y.

October 23-27, 1960—National Electrical Contractors Association, Las Vegas, Nevada.

October 25-27, 1960—American Standards Association, National Conference on Standards, Sheraton-Atlantic Hotel, New York, N. Y.

November 14-18, 1960—National Electrical Manufacturers Association (Annual Meeting), Traymore Hotel, Atlantic City, N. J.

November 27-December 2, 1960—American Society of Mechanical Engineers, Annual Meeting, Statler-Hilton Hotel, New York, N. Y.

FIRST official meeting of Illini Study Club was held January 28 at Elks Club, Decatur, Ill. Left to right at head table: Charles L. Amick, speaker; Gordon Bonvallet, study club chairman; Brooks Chassaing, Midwestern RVP, guiding hand behind the formation of the club. Fifty-one members and guests attended this first meeting of what promises to be an active IES group.

(Continued from page 11A)

these fields and to represent the American viewpoint in the international work. American National Committees for standardization of office equipment and data processing machines have been organized, under proposed sponsorship of the Office Equipment Manufacturers Institute.

Illini Study Club Holds Organizational Meeting

Under the sponsorship of the St. Louis Section of IES and with the cooperation of the Chicago Section, the Illini Study Club held its organizational and first official meeting on January 28, 1960, in Decatur, Ill. Fifty-one present and potential members of IES attending this first study club meeting heard Charles L. Amick, Director of Research, Day-Brite Lighting, Inc., St. Louis, Mo., speak on the revised IES footcandles recommendations and related topics. Midwestern Regional Vice President, Brooks Chassaing, who is in large measure responsible for the organization of this study club, was on hand to provide pertinent data on IES aims, organization and benefits.

The territory tentatively assigned to the Illini Study Club includes such metropolitan centers as Decatur, Mattoon, Springfield, Danville and Champaign-Urbana, territory formerly served by the St. Louis and Chicago Sections.

Temporary officers of the study club, elected at this first meeting are: Chairman — Gordon Bonvallet, Illinois Power Co., Decatur; Vice Chairman—Walter Marquardt, Springfield; Secretary-Treasurer—Don Weatherford, Consulting Engineer, Decatur; Board of Managers — Joe Chamness, Utility Engineer, Mattoon; Al Larson, Graybar Electric Co., Springfield; Max Tepper, Electrical Distributor, Champaign-Urbana, and Gordon Harvey, General Electric Co., Danville.

Nominations Submitted for 1960-1961 IES Officers

Nominations for the 1960-1961 election of IES officers was reported to Council at its February 11 meeting in New York City by the Nominating Committee, Marshall N. Waterman, Chairman. Names to be presented for ballot by the membership are:

President—R. G. Slauer
Second Vice President—G. F. Dean
General Secretary—J. D. Mitchell
Treasurer—W. P. Lowell, Jr.
Directors—A. C. Barr and R. L. Smart

James R. Chambers, elected to a two-year term last year will serve as First Vice President. Also continuing in office are Directors C. L. Amick, J. S. Hamel, R. P. Teele and Joseph Thomas.

Ballots will be mailed to the membership by April 5, 1960, with election results to be tabulated by May 30th.

Electrical Engineers Offer Ten-Week Lighting Course

The Illumination Division of the New York Section, American Institute of Electrical Engineers, is conducting a ten-week course on basic elements of illumination design. The course meets for two-hour sessions each week at the General Electric Co. auditorium in New York City. Fee is $15 for members of AIEE, IES, the American Society of Mechanical Engineers, the American Society of Civil Engineers and the American Society of Mining Engineers; $20 for all others.

Henry Wenson, electrical engineer with the Port of New York Authority, is serv-

(Continued on page 14A)

IES COUNCIL in action. Shown here is only part of the largest Council meeting ever held, February 11, in New York City. At head of table, left to right, R. G. Slauer, First Vice President; J. B. Browder, Jr., President, and (standing) James R. Chambers, Second Vice President.

Oshawa Shopping Center,
Oshawa, Ontario, Canada.

Tip Top Mart, Canton, Ohio.

Sears, Roebuck Store, Tampa, Florida.

Southgate Shopping Center, Cleveland, Ohio.

Garden State Plaza, Paramus, N. J.

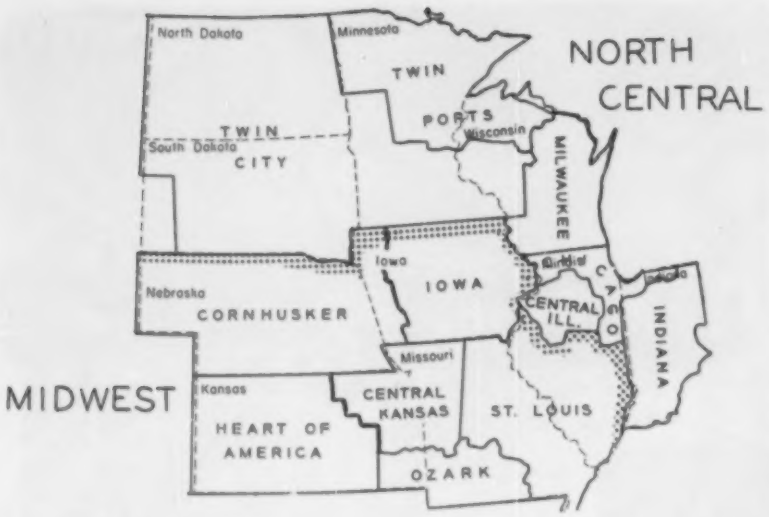
Area Lighting with Monotube Poles offers you unmatched design choice in steel or aluminum

Union Metal engineering assistance is available to help you select the most appropriate lighting pole design combining economy and good appearance.

THE UNION METAL MANUFACTURING COMPANY

Monotube Area Lighting Poles

Canton 5, Ohio • Brampton, Ontario, Canada



MAP showing the division of the Midwestern Region into the North Central and Midwest Regions of IES.

(Continued from page 12A)

ing as coordinator for the course which covers:

February 10—Introduction, Power, Street Lighting—Henry Wenson; W. Appleton, Consolidated Edison Co. of New York; A. Lurkis, Bureau of Gas & Electricity, New York City.
February 17—Coordination of Lighting and Architecture—A. Gordon Lorimer.
February 24—Commercial Lighting—Office—F. Graham, Syska & Hennessy.
March 2—Commercial Lighting — Office — G. Gillen, Consolidated Edison Co. of New York.
March 9—Commercial Lighting — Store — H. Wald, Wald & Zigas.
March 16—Residential Lighting—G. Gillen.
March 23—Industrial Lighting—M. Savitt, Slocum & Fuller.
March 30—Industrial Lighting—M. Schwartz, Walter Kidde Constructors.
April 6—Outdoor Lighting—G. Kelly, Port of New York Authority.
April 13—Ballasts and Dimmers—D. Wilson, General Electric Co. and B. G. Demming, Superior Electric Co.

Midwestern Region Divided Now North Central and Midwest

On the unanimous petition of the 12 Sections and Chapters of the Midwestern Region, Council, at its February 11 meeting in New York City, approved a plan to divide this region into two parts, to be known as the North Central and Midwest Regions of IES.

The North Central Region, composed of the Central Illinois Chapter, Chicago Section, Indiana Section, Milwaukee Section, Twin City Section and Twin Ports Chapter will have a membership of 1021. Forming the new Midwest Region are the Central Kansas Chapter, Cornhusker Section, Heart of America Section, Iowa Section, Ozark Chapter and St. Louis Section for a total membership of 543.

The new regions plan to serve as alternate hosts to the annual regional conference (as is the practice with the Southeastern and South Central Regions), with the 1960 regional scheduled for Sioux City, Ia. (Midwest Region). Twin City Section (North Central Region) will be host to the 1962 regional. Since the 1961 National Technical Conference is to be held in St. Louis, there will be no regional conference that year.

Before its division, the Midwestern Region was the largest in the Society, in terms of total membership and number of Sections and Chapters. The problems concomitant to the size of the region led to the formation of a Task Committee in November, 1957 to study possible solutions to the problems. This committee, composed of James R. Chambers, now Second Vice President of IES and a former Midwestern Regional Vice President; Brooks Chassaing, 1958-1960 Regional Vice President and Joseph A. Schneller, also a past Regional Vice President, led the way toward the present division of the region.

EEI Announces Plans for Annual Sales Conference

The 26th Annual Sales Conference of the Edison Electric Institute has been scheduled for April 4-6, 1960, at the Edgewater Beach Hotel in Chicago. Highlight of the first day's conference program is a general session featuring addresses on "The State of the Industry" by Allen S. King, EEI president and president of Northern States Power Co.; "Live Better Electrically Program" by Ralph Zeuthen, EEI program manager; "Relationship of Sales to Other Departments," G. S. Rawls, Louisiana Power & Light Co., and "Advertising and Motivation Research," Dr. Virginia Miles, Market Planning Corp.

The conference's second day will be devoted to a general session on the "all-electric concept" with speakers representing the architectural, building and manufacturing points of view.

Also included in the meeting schedule are the Sales Promotion Awards luncheon and a number of committee meetings.

Charter Approved for Gulf Coast Chapter, Mobile

At the January 5 meeting of the IES Coucil Executive Committee in New York City, action was taken to approve the application for Charter from the Gulf Coast Chapter in Mobile, Alabama, IES's ninetieth local group. Genesis of this Chapter was the Gulf Coast Study Club, organized in March, 1959, under the sponsorship of the Alabama Section. The new Chapter will be in the South Central Region, encompassing territory formerly included in the Alabama, New Orleans, Mississippi and Suwanee River Sections/Chapters.

Walton Reeves, Moore Handley Hardware Co., is serving as Gulf Coast Chapter Chairman; Secretary is James E. Springer, Alabama Power Co., both of Mobile. Charter presentation was planned for the week of March 7.

Extra-High-Voltage Symposium At AIEE Winter Meeting

International standardization of extra-high-voltage transmission of electric power was proposed by two American Electric Power Service Corp. executives in a paper presented at the extra-high-voltage symposium at the Winter General Meeting of the American Institute of Electrical Engineers, February 2 in New York City. Philip Sporn, president of the company, and H. P. St. Clair, planning and operating engineering manager, suggested that 500,000 volts be adopted as the international standard and consideration be given to 690,000 or 750,000 volts for the future.

At present, there are 2500 circuit miles of 345-kv transmission in this country and several new projects using this voltage are under construction or consideration. Standardization at 500 kv, observed the authors, would meet early requirements for long-distance high capacity transmission in the United States and Canada. A decision on 500 kv, argued Messrs. Sporn and St. Clair, would not only take care of immediate future requirements but would provide a basis for international standardization at that level and lead the way toward future standardization at higher levels.

(Continued on page 17A)

Mister Magoo says:

"By George, whoever dreamed up a *light* like this?"

If you n

GENER
F40CW
PREHEA

1 THE F40

GENER
F40CW
PREHEA

2 THE PREMI

See other side for your best fluorescent buy for new lighting—
G-E POWER GROOVE LAMPS!

now use 4-foot, 40-watt fluorescents,

HERE ARE TWO NEW GENERAL ELECTRIC LAMPS WHICH GIVE YOU MORE LIGHT—AT LESS COST —FROM YOUR PRESENT LIGHTING SYSTEM

ENERAL ELECTRIC
OCW COOL WHITE
EHEAT-RAPID START U.S.A.

The new, **universal** General Electric **F40** Fluorescent Lamp has already become the most popular 4-foot lamp on the market—all brands included. Get increased light output—2800 lumens—from the new G-E **F40** Lamp. You can operate it in either rapid start or starter-type circuits—thus reducing ordering, stocking, record-keeping, and storage, and simplifying maintenance if you use both types of lighting systems. Another plus feature . . . you'll find they list for 5¢ less than previous rapid start lamps.

ENERAL ELECTRIC
OCW 3 COOL WHITE
EHEAT-RAPID START U.S.A. 3

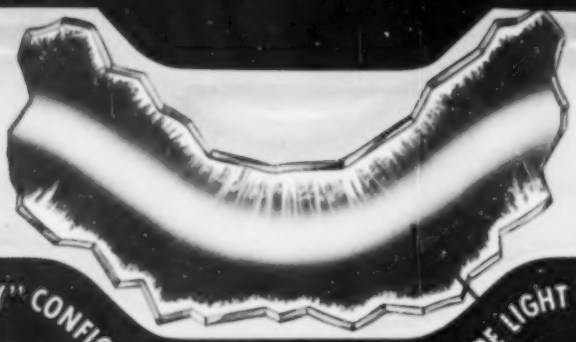
MIUM 3

The dramatic, new G-E **PREMIUM 3** is your best bargain in 40-watt fluorescent light. It can deliver 11% more light than the new **F40**; and if your 40-watt lamps have been in a year or more, you get at least 30-55% more light than from the lamps you're replacing—**overnight!** The **PREMIUM 3** is the first 40-watt fluorescent to crash through the 3000-lumen barrier—designed to deliver 3100 lumens in the cool white color. It's priced slightly higher than the **F40** ($1.45 list)—but will give you lowest cost of light in a 4-foot, 40-watt fluorescent lighting system.

Progress Is Our Most Important Product

GENERAL ELECTRIC

WHERE BRIGHT IDEAS BECOME BETTER LAMPS



IT'S THE "WAVY" CONFIGURATION THAT GIVES YOU MORE LIGHT AT LESS COST!

GENERAL ELECTRIC POWER GROOVE* LAMPS

YOUR BIGGEST BARGAIN IN FLUORESCENT LIGHTING

Of all the lamp manufacturers, only General Electric can mass-produce this unusual lamp that makes all other brands of fluorescent lamps take a back seat. It's the shape that gives the G-E POWER GROOVE Lamp the extra muscle to outshine any previous fluorescent. The double-dimple shape is completely functional—it bends the arc stream, makes it travel further. This means you get more light from each lamp . . . so you need a less extensive, less expensive lighting system to get the amount of light you want.

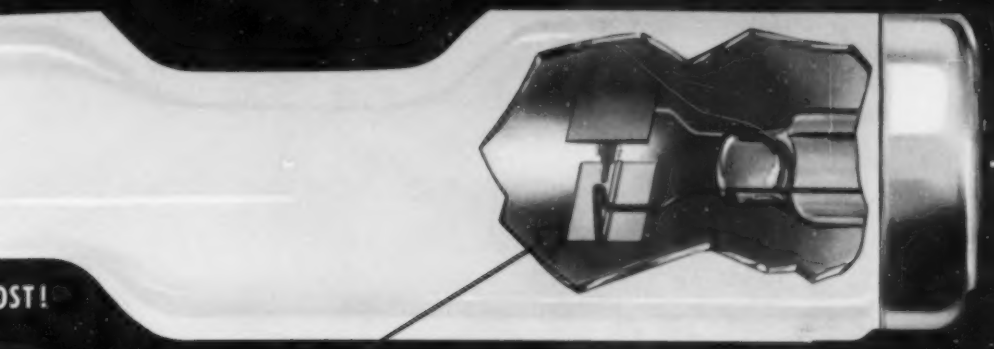
This exclusive, new lamp development is typical of the innovation and performance leadership you get in **every** General Electric Lamp you buy. For more information, write General Electric Co., Large Lamp Dept. C-06, Nela Park, Cleveland 12, Ohio.

SEE OTHER SIDE FOR TWO **OTHER** MONEY-SAVING, NEW G-E LAMPS.

LARGE LAMP DEPARTMENT

GENERAL ELECTRIC

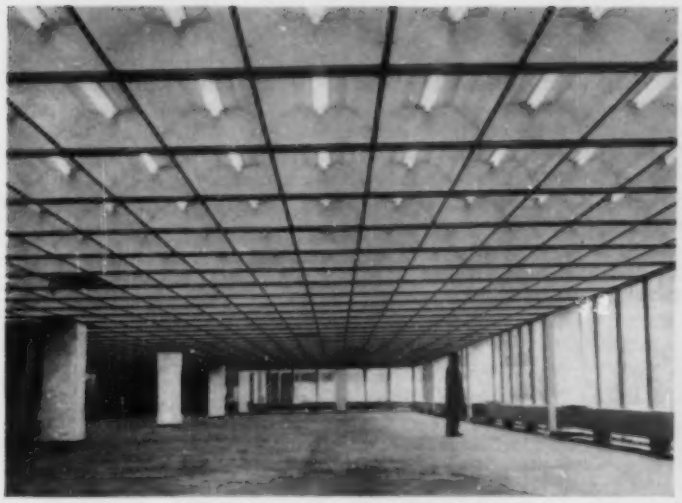
WHERE BRIGHT IDEAS BECOME BETTER LAMPS

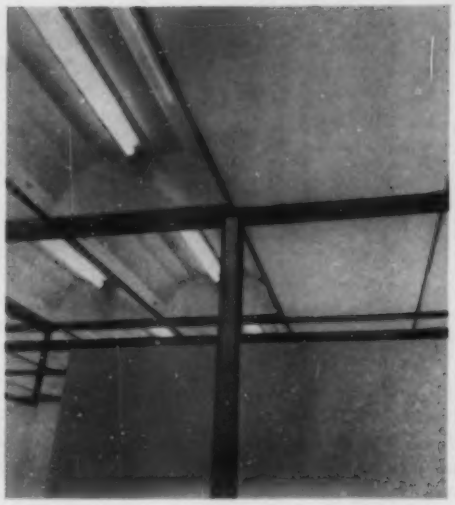


OST!

CATHODE SHIELD improves anode action (reducing end loss) and collects tiny electrode particles that would otherwise land on glass wall, darkening end of tube. New G-E POWER GROOVE Lamp stays brighter—end-to-end—longer!

NEW CONFIGURATION makes arc stream travel in a wavy path; makes greater electric power available for producing light. You get the arc equivalent of a 9-foot lamp; and the longer the arc stream, the more efficient the lamp.





CONTINUOUS plane of contiguous fixtures is ceiling system at Union Carbide Building which, in addition to providing about 80 footcandles of illumination, conceals service equipment hung from slab above, distributes conditioned air, provides top anchor for removable partitions and blocks sound from traveling through the ceiling cavity. Photo at right shows close-up of ceiling before installation of diffusing panels (left) and with the plastic panels installed. Part of the partition panel in this view is keyed into the major runner.

(Continued from page 14A)

In another symposium paper, it was reported that by next May, experimental extra-high-voltage transmission lines near Pittsfield, Mass., will be energized by the General Electric Co. Initial energy will be 460,000 volts, somewhat below the highest transmission voltage presently employed in the Soviet Union, but plans call for eventual experimentation with 750,000 volts, the highest transmission voltage ever used.

Objectives of this project are to help re-establish the United States as a world leader in the field of extra-high-voltage power systems and to prove that these systems (460,000 volts and over) are feasible, more reliable and more economical for the transmission of large blocks of power over smaller rights of way than those systems presently in use.

Since the end of World War II there has been a rapid increase in the use of extra-high-voltage power transmission. More than 12,000 circuit miles of 275-500 kv power lines are in operation or under construction now. Twenty-five per cent of this mileage is in the United States, 20 per cent in the Soviet Union and the remainder in 12 other countries.

Ceiling Symposium at Union Carbide Building

It may be a sign of the times and a peek at the future that a full-scale symposium can be devoted to the ceilings of a modern office building. A panel of seven described the multiple functions of the 20-acre ceiling of New York City's as yet unfinished Union Carbide Building. This was at a meeting held on one floor of the building February 2, attended by some 150 of the architectural and electrical trade press.

From first glimpse, the installation would appear to be a conventional luminous ceiling of plastic panels, designed for lighting of some 80 fc. In detail, however, its design is the product of the acoustical, lighting, heating and sound engineers as well as the architect and contractor. Further details and in-service descriptions will be available after the building is occupied. At the symposium, however, a number of details were discussed of current interest to lighting practitioners.

Developed from the start by the combined efforts of several branches of engineering, and by trial-and-error tests in a life-size mock-up building, the ceiling has four main functions. The continuous plane of contiguous one-lamp fixtures, shielded by plastic diffuser panels provides:

(a) Lighting of about 80 fc uniform in distribution and of comfortable brightness levels.

(b) Dispersion of conditioned air, warm or cool.

(c) Built-in sound-control system.

(d) Top anchor for the specially designed partitions used throughout the building.

Flexibility of partitioning was stressed at the symposium as a priority consideration for any design of the lighting, air conditioning and sound control for this building.

Participating in the symposium, which was sponsored by the Union Carbide Co., were: R. K. Posey, Skidmore, Owings and Merrill; A. L. Windman, lighting engineer for Syska & Hennessey; R. B. Newman, acoustical engineer for Bolt-Beranek and Newman, and Donald Byrne, George A. Fuller Co. H. S. Bunn, president, and K. A. Kettle, project manager, of the Union Carbide Co., presided.

Obituaries

Commander Dean Farnsworth, MSC, USNR, a Fellow of the Illuminating Engineering Society, died on December 27, 1959 at Bethesda Naval Hospital, Bethesda, Md., after a long illness. He was 57.

His professional career, both in the Navy and in civilian life was marked by a long series of contributions in illumination and color vision, most notable of which was his leadership in establishing standards of color, decoration and lighting for maximum psychological comfort in submarines.

Dean Farnsworth began his career as a stage lighting designer and for 14 years was a teacher of stage lighting at Northwestern and New York Universities. He became a research associate in vision in the Psychology Department of New York University in 1940, the beginning of his interest and many contributions to color vision and illumination.

In 1943 he joined the Navy, where he attained the rank of Commander and served as Head of Color Vision Research and Selection of the U. S. Naval Submarine Base, Medical Research Laboratory in New London, Conn. Immediately prior to his illness and death, Commander

(Continued on page 18A)

Commander Dean Farnsworth

(Continued from page 17A)

Farnsworth was Scientific Liaison Officer for the Office of Naval Research in London, England.

In his research in the fields of night vision, dark adaptation, visual acuity, color blindness, color standards, fluorescence and identification signals, he was responsible for numerous designs and inventions including the Farnsworth-Munsell 100-Hue Test (for color blindness), Dichatomous Test for Color Blindness, Navy Lantern for color vision testing, signal light system for Hull Opening Indicator Board and Macbeth-New London Easel Lamp for daylight illumination for vision testing.

Commander Farnsworth joined IES in 1947 and was elected to Fellow grade in 1953. His IES activities included membership on the Color and Illumination Committee from 1947 to 1956, with chairmanship from 1949 to 1950; official IES representative to the Inter-Society Color Council, 1947-1955; Committee on Standards for Quantity and Quality of Illumination, 1954-1957; Marine Transportation Subcommittee of the Committee on Interior Lighting for Public Conveyances, 1956-1957 and Research Executive Committee of the Illuminating Engineering Research Institute, 1955-1956.

He was also an active member of the Inter-Society Color Council, U. S. National Committee of the Commission Internationale de l'Eclairage and Optical Society of America and had many papers published in the journals of scientific organizations.

Professor Georges Destriau, discoverer of electroluminescence died in Cauderan, France, in January at the age of 56. He had been in poor health for a long time.

Last May Professor Destriau visited the United States to present a paper before the Electrochemical Society in Philadelphia. He will be remembered by many IES members for the paper he presented at the 1955 IES National Technical Conference in Cleveland.

Professor Destriau was born on August 1, 1903 in Bordeaux, France. He attended the Sorbonne and the Ecole Centrale des Arts and Manufactures, both in Paris, and received an engineering degree from the latter. In 1936 he was awarded a doctorate by the Sorbonne for work done in the Institut du Radium.

In 1939, Professor Destriau became Charge de Cours at the Faculte des Sciences of the University of Bordeaux, in 1942 he was made Director of Studies of the Ecole Centrale des Arts and Manufactures, Paris. From 1944 to 1953 he served as Charge de Cours at the Faculte des Sciences of the Sorbonne and professor of the Faculte des Sciences of the University of Politiers. In 1953, he was made a professor at the Sorbonne.

Professor Destriau was known primarily for his pioneering work in electroluminescence and related effects of electric fields on phosphors, but he also made several notable contributions in the fields of alpha particle scintillations, x-ray therapy, radiography, optics and the properties of thin metal films.

He was a member of the Societe Francaise de Physique; the Societe Francaise de Chemie-Physique; the Societe Francaise des Electriciens; American Physical Society and the Electrochemical Society.

Bassett Jones, a well-known member in the early days of IES, died on January 23, 1960 at the age of 82.

Stage lighting expert and specialist in the art of lighting public buildings, monuments and other spectacles, Mr. Jones was responsible for supervising and coordinating the lighting at the 1939 New York World's Fair—the first application of commercially made fluorescent lamps. He did much to perfect the use of spot and floodlighting.

Among his IES activities, Mr. Jones was a member from 1921-1922 of the Fixture Manufacturers Committee to Prepare a Code for Fixture Design; 1921-1924, Sky Brightness Committee, and 1925-1927, Natural Lighting Committee.

ABOUT PEOPLE

In a recent announcement, Smitheraft Corp., Chelsea, Mass., made known the appointments of **George T. Wood** as vice president—marketing and **Park R. Hoyt** as vice president—manufacturing. Mr. Wood, who joined Smitheraft in 1957 as marketing manager was formerly sales manager for the midwestern division of the Lewyt Corp. and held sales management positions with Graybar Electric Co. in Tampa, Jacksonville and Atlanta. Mr. Hoyt, a former management consultant who spent 12 years with the Boston firm of Rath and Strong, joined Smitheraft in 1956 as chief industrial engineer.

The board of directors of Kopp Glass, Inc., Pittsburgh, Pa., has elected **Dr. C. E. Leberknight** as vice president—research and engineering and **F. A. Frost** as vice president—production. Dr. Leberknight resigned his professional position at Pittsburgh's Carnegie Institute of Technology to join Kopp in 1942. Mr. Frost, who joined the company in the same year, was formerly affiliated with Manufacturers Light and Heat Co., also in Pittsburgh.

Joel E. Ettinger, president of Omega Lighting, Inc., New York, N. Y. has announced the appointment of **Morton D. Semel** as vice president. Mr. Semel was previously connected with Century Lighting in New York City.

The Edison Medal and the John Scott Award, two major scientific-engineering honors, were presented to **James F. Fairman,** senior vice president, Consolidated Edison Co. and **Dr. Dean A. Lyon,** scientist and consulting engineer, Woodbridge, Conn., respectively, during the opening session of the Winter General meeting of the American Institute of Electrical Engineers in New York City on February 1. The Edison Medal was presented by the AIEE president, **J. H. Foote. G. Curtis Pritchard,** secretary of the Board of Directors of the City Trusts, City of Philadelphia, administrator of the Scott Award, made the presentation to Dr. Lyon in recognition of his invention of the first practical and useful optical coatings for the reduction of light reflections.

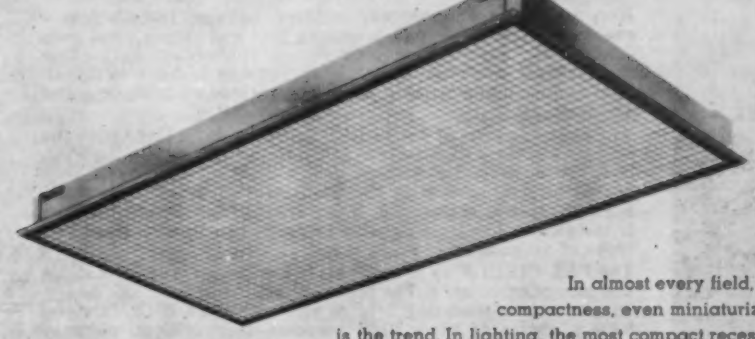
Also at the Winter General Meeting of AIEE, **Clarence H. Linder,** vice president and group executive of the electric utility group, General Electric Co., New York, was nominated for the office of 1960-1961 president of the American Institute of Electrical Engineers.

William P. (Teddy) Bear, Member Emeritus of IES, was recently honored by the City of Los Angeles with an "Outstanding Citizen Award." The tribute was made in recognition of Mr. Bear's activities in civic improvement, particularly in obtaining improved street lighting, increased public transportation and a public library in his community, Panorama City, Calif. An active member of the Panorama City Chamber of Com-

(Continued on page 21A)

It's the year

for compact lighting too!



In almost every field, compactness, even miniaturization, is the trend. In lighting, the most compact recessed fixture designed to fulfill optimum illumination standards is the SHALLOBEAM. This ultra-shallow system is so compact and so self-contained an electrician simply lifts it from the carton and snaps it into the ceiling opening. Modular in concept, nominal 1'x4', 2'x4' and 4'x4' SHALLOBEAMS may be included in the same ceiling plan. A recessed depth of only 4¼" permits installation in ceilings with restricted overhead. Exclusive "I-Beam-like" die-castings and die-formed parts assure unsurpassed sturdiness and precision alignment. A large selection of diffusing and light control mediums are available to meet specific illumination tasks. No visible hinges or latches mar SHALLOBEAM'S clean, architectural appearance. For the most compact lighting with the most extensive versatility and lasting quality specify and install SHALLOBEAM. Write for bulletin D-107

Integral mounting bars automatically release into supporting position.

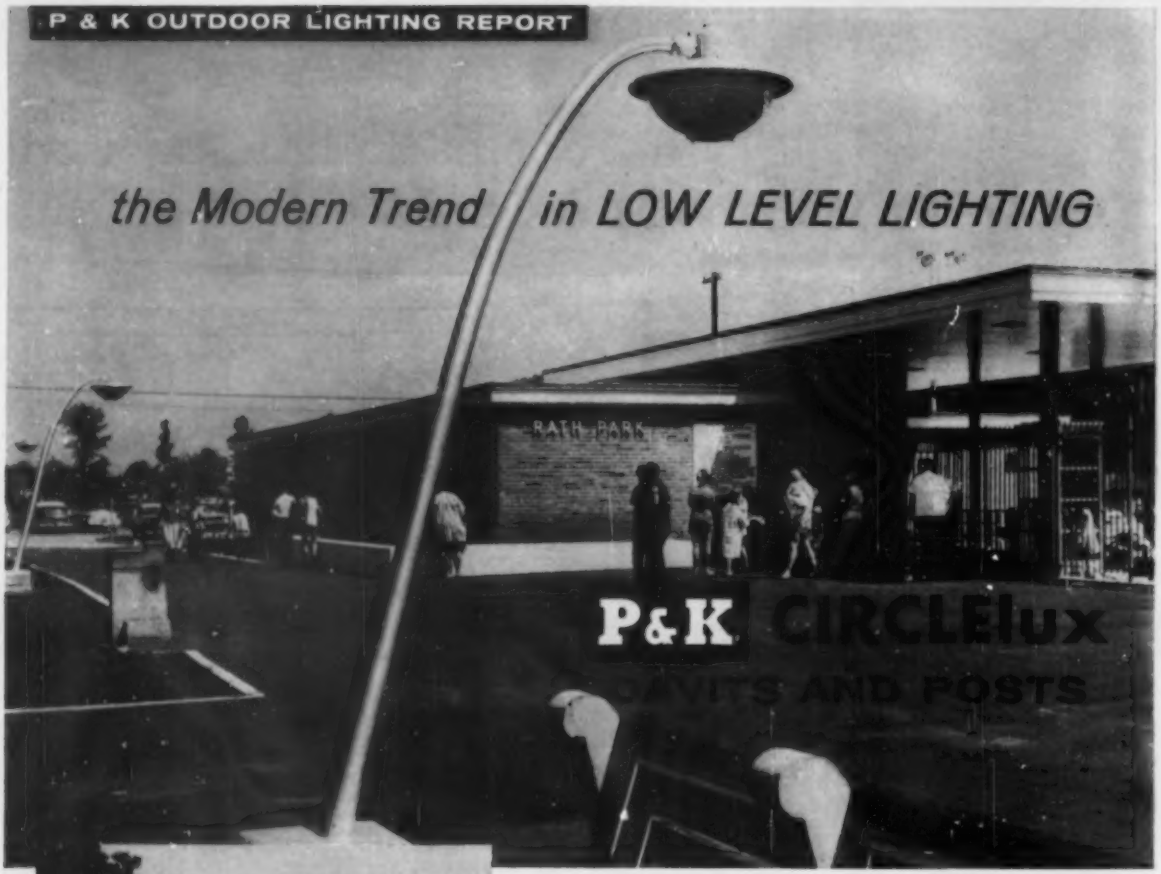
SUNBEAM LIGHTING COMPANY

777 East 14th Place, Los Angeles 21, California

3840 Georgia Street, Gary, Indiana

P & K OUTDOOR LIGHTING REPORT

the Modern Trend in LOW LEVEL LIGHTING



TOP PHOTO: Location: Rath Park, Franklin Square, L. I., N. Y.
Architect: Herbert D. Phillips
Consulting Engineers: Barstow, Mulligan & Vollmer

LOWER PHOTO: Location: Fairleigh Dickinson University, Madison, N. J.
Electrical Consultant: H. L. Sykes

modern lighting at a realistic cost

Here are two contemporary outdoor lighting installations – one an all new municipal swimming pool and recreational area – the other, a prominent New Jersey University. Both chose the P&K all aluminum CIRCLElux lighting package to illuminate and compliment their roadways, walkways, landscape and architecture.

The sweeping lines of the P&K CIRCLElux davit blend with the modern one story architecture of the Rath Park Swimming Pool. Yet, the modern, but stately, design of the P&K CIRCLElux post is in good taste with the traditional architecture of Fairleigh Dickinson University. The CIRCLElux lighting package is the correct low level lighting choice to compliment almost all types of architecture.

The P&K CIRCLElux is available in a wide range of davit styles and mounting heights. The post is available in one basic design but at various mounting heights and with the CIRCLElux you have a choice of three light sources – incandescent, mercury vapor and fluorescent. This combination of luminaires and davits or posts will enable you to specify "packaged" lighting units. This means easier specifying by using matched components which in turn can customize your lighting projects.

Send in your reservation now for the *new* CIRCLElux catalog.

P&K **PFAFF & KENDALL 84 FOUNDRY ST., NEWARK 5, N. J.**

BRANCH SALES OFFICES: MIAMI, FLORIDA; BURLINGAME, CALIFORNIA
IN CANADA: POWERLITE DEVICES, LTD., TORONTO, MONTREAL, VANCOUVER
EXPORT REPRESENTATIVE: PHILIPS EXPORT CO., NEW YORK, N. Y.

(*Continued from page* 18A)

merce, and presently serving as its treasurer, Mr. Bear is the only non-merchant, non-businessman ever to serve on the Chamber's Board of Directors.

The Pittsburgh Reflector Co., Pittsburgh, Pa., has been reorganized under **Vincent E. Oswald,** new president and chairman of the board. Newly named to vice-presidential posts are **Harold Siler**—sales; **John S. Frizzell**—engineering and sales promotion and **Donald M. Fink**—production operation. **Donald J. O'Neill** has been promoted to the position of assistant to the president with responsibility for supervision of the company's offices in Irwin, Pa. **Harry Restofski** has been retained as advisory consultant to Pittsburgh Reflector and **John Olesh** becomes supervisor of accounting.

The promotion of **F. Crampton Frost** to the administrative staff has been announced by the American Standards Association. Mr. Frost, who will devote full time to membership development, was formerly civil engineer in charge and secretary of the Construction Standards Board and the Materials and Testing Standards Board. These duties are now the responsibility of **H. Warner Dailey.**

R. B. Brown, Jr., a past president of IES, has been promoted to staff assistant to the general sales manager of the Boston Edison Co., Boston, Mass. This appointment, which was effective December 1, 1959, carries with it the responsibility for all training programs in the company's three commercial departments, coordination of promotional programs, preparation of the annual sales plan and editorial work in connection with a proposed monthly customer bulletin. In addition, Mr. Brown will understudy **Julius Daniels,** an assistant to the general sales manager, who is scheduled to retire in July. Prior to this promotion, Mr. Brown had been head of the company's Commercial Lighting Sales Division, a position he had held since 1927.

Several new appointments have been announced by the John C. Virden Co., Cleveland, Ohio. **William C. Giesse** was named to the newly created position of sales promotion manager with responsibility for planning and execution of sales promotion and advertising programs in cooperation with the divisional sales and advertising managers and, in addition, will contribute to the over-all activities of the central marketing department. **John J. Gutwalk** was appointed chief industrial engineer for the firm. The Virden Lighting division of the company has announced the promotion of **Dale A. Gunther** to district sales manager for the northeast region, with territory to include all of New England, eastern New York, New Jersey, Maryland, Delaware and eastern Pennsylvania. Two new sales representatives signed by Virden are **Richard J. Fintze** for the Michigan area and **John C. Dannemiller** for Kansas and western Missouri.

EXPERIMENTAL automobile headlight offers a glimpse at the future in this field. Headlight uses combined reflector-aperture fluorescent lamp extended across the grille of a car between conventional incandescent headlamps.

Robert D. Forger has joined the Society of Plastics Engineers as administrative assistant on the national office staff. Mr. Forger, who will work closely with local Sections and provide staff assistance to committees handling technical meetings, will have as his major responsibility the implementation of the Society's public-relations program.

Michael Lechner has been named director of manufacturing for Litecraft Manufacturing Corp.'s Passaic, N. J. plant. In his new capacity, Mr. Lechner will be responsible for all phases of the manufacture of incandescent and fluorescent lighting fixtures.

Crouse-Hinds Co., Syracuse, N. Y. has announced the appointment of **Austin D. Vanderbilt** as manager of industrial engineering, responsible for coordination of the work of the plant engineering, planning, standards, quality control and safety departments of the firm. Also announced was the promotion of **Richard W. Scott** to administrative engineer in the Engineering Division. Mr. Scott who had been Great Lakes Division manager since 1957, with offices in Detroit, will now make his headquarters in Syracuse.

E. H. Greppin, one of the pioneers of modern surgical and dental lighting, retired from the administrative position of chief lighting engineer at Wilmot Castle Co., Rochester, N. Y., to establish his own consulting engineering firm. Mr. Greppin will continue to act as consultant to the company.

The Austin Co., international engineering and construction firm, with headquarters in Cleveland, Ohio, has announced the establishment of a new company in Argentina, with headquarters in Buenos Aires. **Cyril F. Prideaux,** IES member, has been named president of the firm, which will be known as Austin, Ingenieria y Construcciones, S.A., Comercial, Inmobiliaria e Industrial. Mr. Prideaux, who will continue as president of Austin's Brazilian company, with offices in Sao Paulo, will direct the staff responsible for Argentine location surveys, plant design, engineering and construction work.

Pfaff and Kendall, Newark, N. J. has named **Matt Cabot** as their new lighting representative for the state of Hawaii. Mr. Cabot, who operates out of Honolulu, will handle the company's outdoor lighting line. Before moving to Hawaii, Mr.

(*Continued on page* 22A)

(*Continued from page 21A*)

Cabot was western sales manager for Day-Brite Lighting, Inc., and is now serving as the Day-Brite representative in St. Louis, in addition to his activities for Pfaff and Kendall.

General Electric Co. has announced several new appointments in their Lamp Division. **Donald D. Scarff,** formerly western region sales manager, has been named general manager of the Large Lamp Department, replacing Lamp Division general manager **Herman L. Weiss,** who has been serving as acting department manager since December 1959. In the Miniature Lamp Department, **John S. Harrington** has been named manager of decorative lamp sales and **David C. Miller** is now manager of original equipment sales. Also announced by G-E is the reorganization of its Apparatus and Industrial Group into two components, an Industrial Group and an Electric Utility group. **Arthur F. Vinson,** vice president and former group executive of Apparatus and Industrial Group will be the executive of the new Industrial Group. **Clarence H. Linder,** vice president formerly in charge of Engineering Services will head the new Electric Utility Group. An announcement from the General Electric Supply Co. names IES Southwestern RVP, **John B. Deck, Jr.,** as district lamp and lighting specialist for the Dallas, Fort Worth, Waco, Tyler, Abilene, Lubbock, Midland and El Paso trade areas. Mr. Deck was formerly with Texas Power & Light Co., Dallas, where he was in charge of lighting sales promotion for 12 years.

Paul M. Dollard, management consultant of Ebasco Services, Inc., New York, has been appointed to the firm's general management consulting staff. Prior to joining Ebasco, Mr. Dollard had been president and general manager of Central Foundry Co. of New York and president of Century Engineers, Inc., Burbank, Calif.

Sylvania Electric Products, Inc., has announced three new appointments for the Parts Division in Warren, Pa. **J. Marshall Smith** was named plant manager for wire operations with responsibility for the manufacturing operations of the plant, which produces fine wire and ribbon to exact specifications. He succeeds **Henry McConnell** who has resigned. New plant manager for the metal base plant is **Raymond N. Anderson** who will be in charge of all operations in the production of aluminum "bayonet type" photoflash bases and "threaded type" incandescent lamp bases. **Robert F. Scalise** will be district sales manager for the Warren Parts Division, responsible for sales in ten southeastern and mid-central states and the province of Ontario, Canada. Representatives from the Warren and Cincinnati sales offices of the Division will report to Mr. Scalise. In another Sylvania announcement, **Arthur L. Milk** was appointed special sales representative for the company, to cover the southeastern region from headquarters in the Cocoa-Cape Canaveral area. Mr. Milk will work in close coordination with regional sales personnel from the company's various operating divisions.

Metalcraft Products Co., Philadelphia, Pa. has named **Herbert Wile, Jr.** to the position of advertising manager. Mr. Wile was formerly an account executive and service manager for the David Zibman Advertising Agency. Also announced by the company were the appointments of two new sales representatives: **Robert J. Kuzell,** Kuzell and Co., Decatur, Ga. for the Georgia, Alabama and South Carolina area and **Charles C. Laney,** Charles C. Laney Agency, Richmond, Va. for eastern Virginia and North Carolina.

The appointment of **James M. Arthur** as regional sales manager, northeastern region, has been announced by Silvray Lighting, Inc., Bound Brook, N. J. Formerly assistant to the vice president, Mr. Arthur will now be completely in charge of all sales management, marketing and service functions throughout the New England states, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia and the District of Columbia. Prior to joining Silvray in 1958, he was associated for 34 years with the Graybar Electric Co., Inc., New York City.

The Prescolite Manufacturing Corp., Berkeley, Calif., has promoted **Al Thompson** to the post of Bay Area sales manager. Mr. Thompson, working out of the company's home offices, will direct the sales of the firm's entire line of lamps and lighting fixtures in his territory. Prior to assuming this new position, Mr. Thompson served as Bay Area salesman and Prescolite representative in the Colorado-Wyoming territory.

Stephen N. Krist, general manager of Kerrigan Iron Works Co., Nashville, Tenn., has announced the appointment of **Ted Nemes** as sales manager of the Lighting Standard Division. Mr. Nemes has formerly been associated with the Cory, Admiral and Fedders Corps.

McPhilben Lighting, Inc., Brooklyn, N. Y., has named **Edward L. Gluck** to the position of sales manager, effective January 15, 1960. Mr. Gluck has been associated with McPhilben for the past five years, most recently in the position of eastern sales manager. Prior to his association with McPhilben, he had been a senior sales engineer for Holophane Co., Inc., New York, N. Y.

Jay Lighting Mfg. Co., Brooklyn, N. Y., has announced the promotion of **Leon Goldberg** to manager—midwestern sales office. Mr. Goldberg will make his headquarters in Skokie, Ill. Also announced by Jay was the appointment of **W. E. Briscoe, Jr.** as sales representative for the New Mexico, Oklahoma and northern Texas territory, with offices in Dallas, Texas.

The Wakefield Co., Vermilion, Ohio, has announced the following new sales assignments: **Ronald H. Mason** for Milwaukee; **Art Henson, Tom Lister, Bill Sanders** of Dynamic Industrial Sales Co. for Detroit; **James Clarke** for Columbus; **Don Congdon** at Denver; **Richard Marshall** for Charlotte, N. C. and **Walter Jerkins** for Jacksonville, Fla.

Tork Time Controls, Inc., Mount Vernon, N. Y., has appointed **Verlyn H. Branham Sr. and Jr.,** partners in the Atlanta firm of Verlyn H. Branham & Son, as southern representatives. Mr. Branham, Sr. has been a lighting fixtures

(*Continued on page 25A*)

IES Membership Directory—See Index to 1959

Your copy of the Personnel Index in the Annual IES Indexes, published as Section II of the January 1960 issue of IE, is a valuable reference for addresses and business affiliations of IES officers and committee personnel — active Society members. Save your Index for use in IES business all through the coming year.

What more important single factor is there in an Art Museum, besides the paintings themselves, than the light to see them by?

EXTRU-LITE† SPECIFIED BY

AMERICAN LIGHTING CORP. FOR

SOLOMON R. GUGGENHEIM MUSEUM

DESIGNED BY

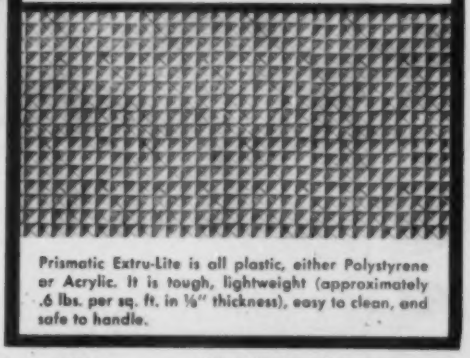
FRANK LLOYD WRIGHT

Frank Lloyd Wright designed the architecture to capture the daylight. Within the building, the fluorescent lighting cleverly blends with the natural light. Result: High level, glareless illumination . . . ideal for viewing art.

James Johnson Sweeney, Director of the Museum, Alfred Binder, Illuminating Engineer and Designer for American Lighting Corp., and A. E. Alper, Installation-Engineer of Daylight Elec. Construction Corp., are the men responsible for this tremendously effective lighting application. Much credit is due them for their new concepts of creation, courageous experimentation and zeal for perfection. That EXTRU-LITE was chosen is a tribute to its shielding excellence.

On the interior frontal ramp, 3-lamp fluorescent Luminaires are hung flush to the ceiling with the light source placed at an angle of abt. 40 degrees. The Luminaires form a U (see illus.) conforming to the gallery shape.

Each Luminaire uses 3 lamps. The ratio of illumination is approx. 2 to 1 in lumens — Cool White to Warm White. Crystal-clear EXTRU-LITE, (Rotuba's extruded plastic shield having over 9,000 prisms per sq. ft. and here made with Plexiglas®†) combines the 2 colors to achieve a diffuse, warm-enlivened light. Further, it gives brightness control with the desired illumination level in the viewing area.



Prismatic Extru-Lite is all plastic, either Polystyrene or Acrylic. It is tough, lightweight (approximately .6 lbs. per sq. ft. in ⅛" thickness), easy to clean, and safe to handle.

Besides this highly publicized, highly specialized Museum job, Extru-Lite has been used successfully for over 5 years in thousands of installations, such as schools, banks, office buildings, hospitals and churches.

That's why we say, for the Best Buy in Sight
— Specify Fixtures using EXTRU-LITE.

Send for our Fact Sheet and Samples today

ADDITIONAL OFFICES: O'Connell & Associates, Chicago, Ill., Ambassador 2-5841; Robert L. Bouse Co., Flourtown, Pa. (Phila.) Chestnut Hill 8-1010

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THE ROTUBA EXTRUDERS, INC.

A DIVISION OF WALJOHN PLASTICS, Inc.

MAKERS OF PLASTIC EXTRUSIONS FOR INDUSTRY

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† Rohm-Haas
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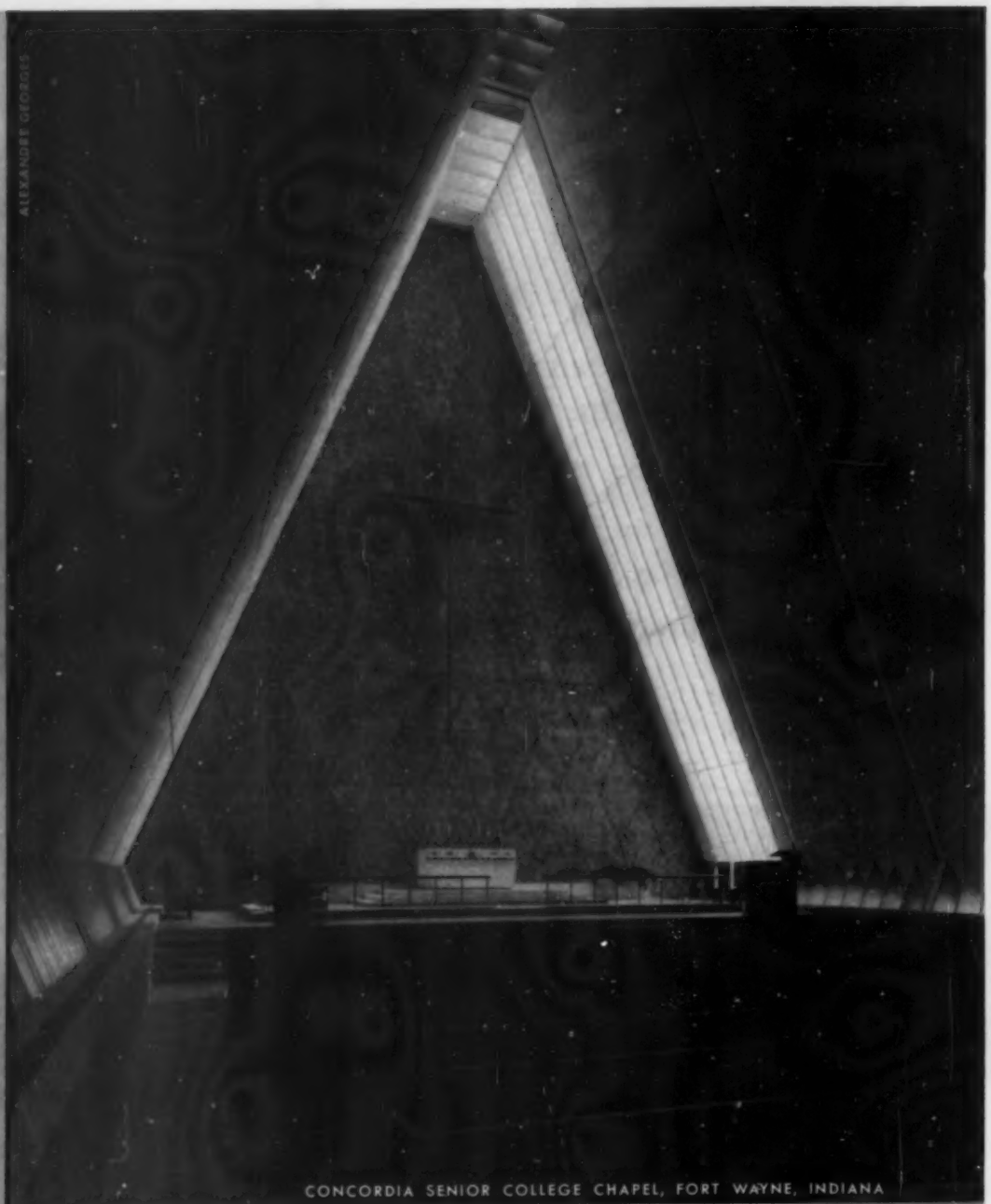
RAMBUSCH LIGHTING



ALEXANDER GEORGES

CONCORDIA SENIOR COLLEGE CHAPEL, FORT WAYNE, INDIANA

ARCHITECT: EERO SAARINEN & ASSOCIATES

RAMBUSCH DOWNLITE

For twenty years, the Rambusch Downlite has been used in lighting literally thousands of lofty interiors such as Banks and Churches. You benefit by this experience when you specify Rambusch. And you get a classic lighting device that is engineered as well as it is well made.

40 WEST 13th STREET, NEW YORK 11, NEW YORK

(*Continued from page 22A*)

salesman in Atlanta since 1922; his son became a partner in the firm in 1950.

Joseph Ollinger & Associates have been named sales representative for Duray Fluorescent Manufacturing Co., Chicago, Ill., for the territory of Kentucky, Indiana and Illinois, south of Peoria. The firm has its main office in Indianapolis, Ind., with a branch in Louisville, Ky.

George B. Weinhold has been named representative in the Ohio Valley area for the lighting sales department of Corning Glass Works, with headquarters in Ingomar, Pa. Mr. Weinhold succeeds **Percy C. Saxton** who retired on March 1.

Robert E. Lewis, president of Sylvania Electric Products, Inc., has been elected a Trustee of the Polytechnic Institute of Brooklyn, according to a recent announcement by **Preston R. Bassett,** Chairman of the Board of Trustees and retired president of the Sperry Gyroscope Co.

Deaths

Merritt W. Gordon, Eastern New York Section.

T. M. Richardson, Central Oklahoma Chapter.

Richard M. Talbot, Pittsburgh Section.

E. W. Bunnel, Inland Empire Chapter.

NEW MEMBERS

At the meeting of the IES Council on February 11, 1960, the following were elected to membership. Names marked * are transfers from Associate Member grade. Names marked ** are transfers from Student Member grade.

ALABAMA SECTION

Members:

Cole, M. B., Gibson Mfg. Co., Box 381, Roanoke, Ala.

*Shook, A. S., General Electric Co., Birmingham, Ala.

Associate Members:

Bratcher, H. E., Juneman Electric Co., Birmingham, Ala.

Cain, J. B., General Electric Supply Co., Birmingham, Ala.

Lovin, W. A., Alabama Power Co., Tuscaloosa, Ala.

Richards, C. F., General Electric Supply Co., Birmingham, Ala.

Walters, Ned, John C. Virden Co., Birmingham, Ala.

ARIZONA SECTION

Associate Member:

Peter, D. J., Safety Engineering & Supply Co., Inc., Phoenix, Ariz.

ARKANSAS CHAPTER

Associate Member:

Hibbard, W. F., Richard W. Groh, Architect, Little Rock, Ark.

ARROWHEAD CHAPTER

Member:

*Ritter, W. H. Jr., California Electric Power Co., San Bernardino, Calif.

Associate Members:

Collins, F. M., Tri-County Electric, Riverside, Calif.

Nelson, J. R., Tri-County Electrical Wholesalers, San Bernardino, Calif.

Stapp, J. C., California Electric Power Co., Palms, Calif.

Stelk, Ray, Electric Air Conditioning, San Bernardino, Calif.

BRITISH COLUMBIA SECTION

Associate Member:

Holland, D. E., M. A. Thomas, P.E., Vancouver, B. C.

BUCKEYE CHAPTER

Members:

*Beadle, H. E., North American Aviation, Inc., Columbus, Ohio.

*Smith, W. T., Columbus & Southern Ohio Electric Co., Columbus, Ohio.

*Waggener, Blanche, Columbus & Southern Ohio Electric Co., Columbus, Ohio.

Associate Member:

Tuttle, H. L., Robert S. Curl & Associates, Columbus, Ohio.

CAPITAL SECTION

Associate Members:

Barkley, Joan C., Potomac Electric Power Co., Washington, D. C.

Bauer, F. G., Engelhard Industries, Inc., Arlington, Va.

CENTRAL NEW YORK SECTION

Associate Members:

Dishaw, H. H., Galson & Galson, Consulting Engineers, Syracuse, N. Y.

Passage, R. W., Graybar Electric Co., Inc., Syracuse, N. Y.

CHICAGO SECTION

Members:

*Francis, R. M., Benjamin Electric Mfg. Co., Des Plaines, Ill.

*Kochale, E. P. Jr., Benjamin Electric Mfg. Co., Des Plaines, Ill.

*Mided, Louis, Good Mfg. Co., Inc., Chicago, Ill.

*Priestap, K. G., General Electric Co., Chicago, Ill.

*Stepanek, W. J., Sylvania Electric Products Inc., Melrose Park, Ill.

*Vandercook, R. G., The Pyle-National Co., Chicago, Ill.

Associate Members:

Asmus, Cornelis, Jefferson Electric Co., Bellwood, Ill.

Benjamin, Burton, Revere Electric Mfg. Co., Chicago, Ill.

Carleton, R. L., Sylvania Electric Products, Inc., Melrose Park, Ill.

Daniels, J. V., Kemlite Laboratories, Inc., Chicago, Ill.

Mirot, J. G., Jules G. Mirot, Architect, Glencoe, Ill.

Stewart, R. A., Bonny Electric Supply Co., Forest Park, Ill.

Wood, T. H., Cecil B. Wood, Inc., Rockford, Ill.

CHINOOK CHAPTER

Associate Members:

Barker, W. C., Barker Electric Ltd., Calgary, Alta.

Campbell, Alexander, Power Contracting and Equipment, N.W. Calgary, Alta.

Falck, J. D., Haddin, Davis & Brown, Ltd., Calgary, Alta.

Luft, M. F., Canadian General Electric Co. Ltd., Calgary, Alta.

Rogers, C. A., Cochrane Stephenson (Western) Ltd., Calgary, Alta.

Stady, F. V. A., Holden Co., Ltd., Calgary, Alta.

CLEVELAND SECTION

Members:

*Clark, C. N., General Electric Co., Nela Park, Cleveland, Ohio.

*Tisdale, A. H., Ohio Edison Co., Bellevue, Ohio.

Lakness, M. A., General Electric Co., Cleveland, Ohio.

Associate Members:

Gatz, J. J., Advance Transformer Co., Maple Heights, Ohio.

Griffin, J. D., Jr., Westinghouse Electric Supply Co., Cleveland, Ohio.

Klein, S. L., N L Corporation, Cleveland, Ohio.

Kormos, M. J., 16206 Cloverside Ave., Cleveland, Ohio.

McDermitt, W. F., Union Metal Manufacturing Co., Canton, Ohio.

Misenko, J. J., Parma Heights Electric, Parma Heights, Ohio.

COASTAL BEND CHAPTER

Associate Member:

Halliburton, S. G., Westinghouse Electric Supply Co., Corpus Christi, Texas.

CONNECTICUT SECTION

Associate Members:

Mason, S. A., Bryant Electric Co., Bridgeport, Conn.

Tizian, S. L., Muzzillo & Tizian, Stamford, Conn.

CORNHUSKER SECTION

Associate Member:

Johnson, C. H., Omaha Public Power District, Omaha, Nebr.

DIABLO SECTION

Associate Member:

Storrs, R. A., Pacific Gas & Electric Co., Concord, Calif.

**Peterson, E. H., 5229 Burlingame Ave., Richmond Annex, Calif.

EASTERN PENNSYLVANIA SECTION

Associate Members:

Bringman, H. D., Pennsylvania Turnpike Commission, Harrisburg, Pa.

Hallman, D. J., Lehigh Associates, Inc., Allentown, Pa.

Wilson, R. S., Scranton Electric Construction Co., Scranton, Pa.

EDMONTON CHAPTER

Associate Members:

Baldwin, G. H., Industrial Power Installations, Ltd., Edmonton, Alta.

Brocklehurst, B. R., Bruce Robinson Electric (Edmonton) Ltd., Edmonton, Alta.

Burnett, George, Angus Butler & Associates, Edmonton, Alta.

McKernan, P., Canuck Electric Ltd., Edmonton, Alta.

FLORIDA SECTION

Associate Member:

McGinnis, R. J., Hughes Supply, Inc., Sarasota, Fla.

FOREIGN NON-SECTION

Members:

*Campbell, H. G., The Benjamin Electric Co., Brantwood Road, Tottenham, London, England.

Hamman, Mrs. Grace C., P.O. Box 69, Kailua-Kona, Hawaii.

FOREST CITY (LONDON) CHAPTER

Associate Members:

Daly, R. J., Canadian Westinghouse Co., Ltd., London, Ont.

Jennings, R. E., Canadian Westinghouse Co., Ltd., London, Ont.

Vander Heiden, John, Public Utilities Commission, London, Ont.

Wallace, D. N., 255 Horton St., London, Ont.

(*Continued on page 26A*)

(*Continued from page 25A*)

GEORGIA SECTION

Associate Members:

Rodgers, Bernard, Georgia Alabama Supply Co., West Point, Ga.
Taylor, J. H., General Electric Co., Atlanta, Ga.

GOLDEN GATE SECTION

Members:

*Burson, J. H., Westinghouse Electric Corp., San Francisco, Calif.
*Cammisa, Mel., Mel Cammisa, Consulting Engineer, San Francisco, Calif.
*Larissou, J. P., G. M. Simonson, Consulting Engineer, San Francisco, Calif.
*Smith, G. W., Smith & Garthorne, San Francisco, Calif.
*Weiss, W. W., Pacific Gas & Electric Co., San Francisco, Calif.

Associate Members:

Carli, R. C., Graybar Electric Co., San Francisco, Calif.
Croco, C. C., Pacific Gas & Electric Co., Santa Rosa, Calif.
Gill, J. M., Pacific Gas & Electric Co., San Mateo, Calif.
McCullough, J. J., Jr., 26491 Tyrrell Ave., Hayward, Calif.
**Schmidt, G. H., Pacific Gas & Electric Co., San Francisco, Calif.
Strawick, R. J., General Electric Co., San Francisco, Calif.

GOLDEN WEST CHAPTER

Associate Member:

Heseltine, Frank, Canada Wire-Cable Co., Ltd., Regina, Sask.

INDIANA SECTION

Associate Members:

Jeffries, P. E., Ammerman, Davis & Stout, Inc., Indianapolis, Ind.
Lay, C. R., Indiana & Michigan Electric Co., Marion, Ind.

INLAND EMPIRE CHAPTER

Associate Members:

Davenport, E. J., The Washington Water Power Co., Davenport, Wash.
Wessels, J. W., Columbia Electric, Spokane, Wash.

IOWA SECTION

Member:

*Parish, W. L., Parish & Richardson, Architects, Davenport, Ia.

MARITIME CHAPTER

Associate Member:

Scribner, R. D., Sylvania Electric (Canada) Ltd., Montreal, Que.

MARYLAND SECTION

Associate Member:

Wisch, R. E., Baltimore Gas & Electric Co., Baltimore, Md.

MEXICO CHAPTER

Associate Members:

Sanchez de Cima, Alejandro, Jr., Casa Riojas, Rosas Moreno No. 97, Mexico, D. F.
Sanchez de Cima, Francisco, Casa Riojas, Rosas Moreno 97, Mexico, D. F.

MIAMI VALLEY CHAPTER

Associate Members:

De Brosse, C. J., The Dayton Power & Light Co., Dayton, Ohio.
Lyons, Al, Lyons Electrical Supply Co., Dayton, Ohio.

MICHIGAN SECTION

Member:

*Hall, F. L., Jahr-Anderson-Machida Associates, Inc., Dearborn, Mich.

Associate Members:

Anger, W. H., Jr., General Electric Supply Co., Detroit, Mich.
Bond, J. L., General Electric Supply Co., Detroit, Mich.
deDoes, A. N., Detroit Edison Co., Detroit, Mich.
Di Clemente, Gino, R. H. Stellwagen, Consulting Engineers, Detroit, Mich.
Lang, K. E., Superior Electric Co., Dearborn, Mich.
Martin, J. A., 15762 Ashton Road, Detroit, Mich.
Rose, J. E., Detroit Edison Co., Birmingham, Mich.
Togesen, A. A., Alva A. Togesen, Detroit, Mich.
Wolfe, Doris, Consumers Power Co., Jackson, Mich.

Student Member:

Newby, Marvin, 15810 Normandy, Detroit, Mich.

MILWAUKEE SECTION

Member:

*Leister, T. H., Line Material Industries, S. Milwaukee, Wis.

Associate Members:

Clarey, L. R., Northwestern Mutual Life Insurance Co., Milwaukee, Wis.
Curtin, P. J., Line Material Industries, S. Milwaukee, Wis.
Foster, J. C., Wisconsin Power & Light Co., Madison, Wis.
Herzberg, D. E., Electric Supply Corp. of Wisconsin, Milwaukee, Wis.
Kampa, E. L., Allis Chalmers Mfg. Co., W. Allis, Wis.
Nelson, J. S., Thomas Industries, Inc., Milwaukee, Wis.
Reinhold, P. A., Line Material Industries, Milwaukee, Wis.
Schraith, E. F., Line Material Industries, Milwaukee, Wis.
Ward, Jack, Emerson Electric Mfg. Co., Milwaukee, Wis.

MISSISSIPPI CHAPTER

Member:

*Strahan, C. E., Jr., Mississippi Power & Light Co., Jackson, Miss.

Associate Members:

Barlow, H. G., Jr., Leigh Watkins Associates, Jackson, Miss.
Blackwell, Leo, Southern Electric Supply Co., Inc., Meridian, Miss.
Broadaway, R. G., Cabell Electric Co., Jackson, Miss.
Regan, Murray, Mallet & Associates, Jackson, Miss.
Smith, D. T., 3100 Old Canton Rd., Jackson, Miss.
White, J. S., 4005 N. State, Jackson, Miss.
Baughman, W. T., Richard E. Cope, Consulting Engineer, Jackson, Miss.

MONTREAL SECTION

Member:

Lafontaine, A., City of Montreal, Montreal, Que.

Associate Members:

Buckland, C. S., Northern Electric Co., Ltd., Montreal, Que.
Gray, Nesbit, Shawinigan Buildings Ltd., Montreal, Que.
MacDonald, N. A., Northern Electric Co., Ltd., Montreal, Que.

(*Continued on page 40A*)

1960 Regional Conferences—IES

Region	Date and Place	Chairman
South Central and Southeastern	April 21-22 Peabody Hotel Memphis, Tenn.	J. F. Fletcher Standard Electric Co. 876 Vance Ave. Memphis, Tenn.
Southwestern	April 25-26 Robert Driscoll Hotel Corpus Christi, Texas	B. L. Guess, Jr. 1210 York Ave. Corpus Christi, Texas
Inter-Mountain	April 28-29 Mountain Shadows Resort Scottsdale, Ariz.	D. L. Ruff Arizona Public Service Co. Phoenix, Ariz.
South Pacific Coast	May 3-5 Hollywood Roosevelt Hotel Hollywood, Calif.	William Shalda Shalda Mfg. Co., Inc. P. O. Box 507 Burbank, Calif.
Pacific Northwest	May 9-10 Benjamin Franklin Hotel Seattle, Wash.	G. D. King Sylvania Electric Products 3466 E. Marginal Way Seattle, Wash.
Midwestern	May 12-13 Sheraton-Martin Hotel Sioux City, Ia.	Mark Lee and C. R. Tracy Iowa Public Service Co. Sioux City, Ia.
Great Lakes	May 16-17 Carter Hotel Cleveland, Ohio	R. D. Churchill General Electric Co. Nela Park, Cleveland, Ohio
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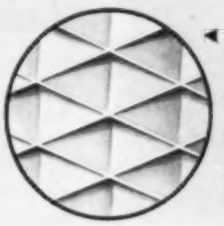

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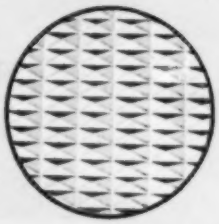

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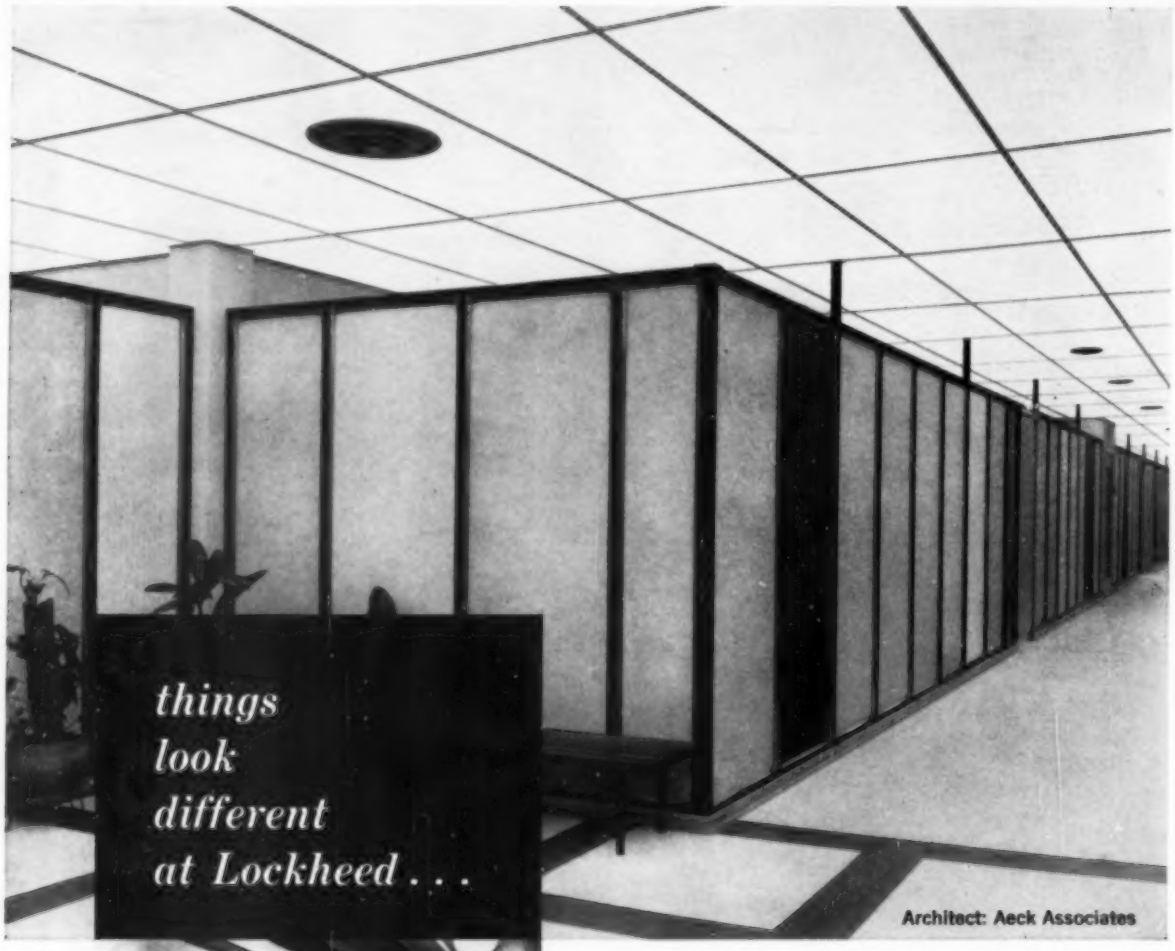

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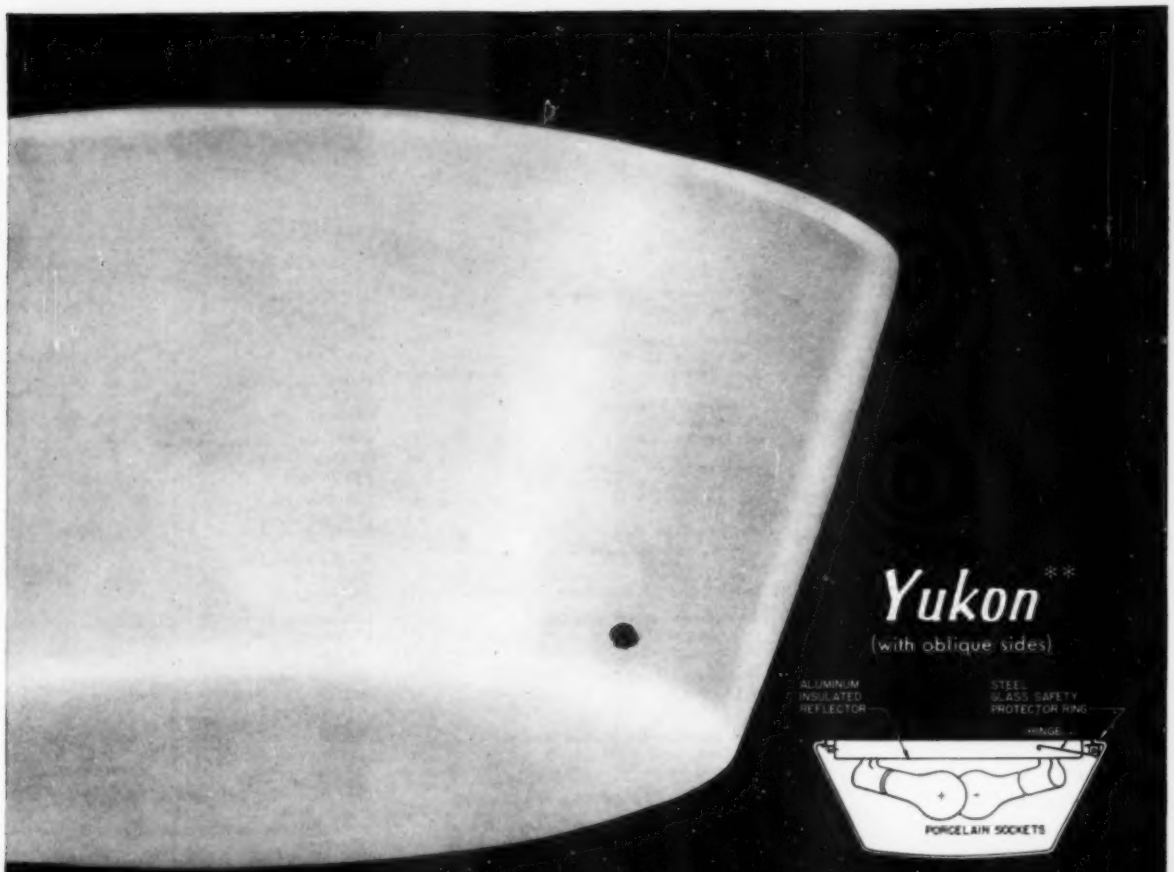

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Kingsport, Tenn. — *J. E. Wright*

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Swissvale
Pittsburgh 18, Pa. — *C. E. Leberknight*

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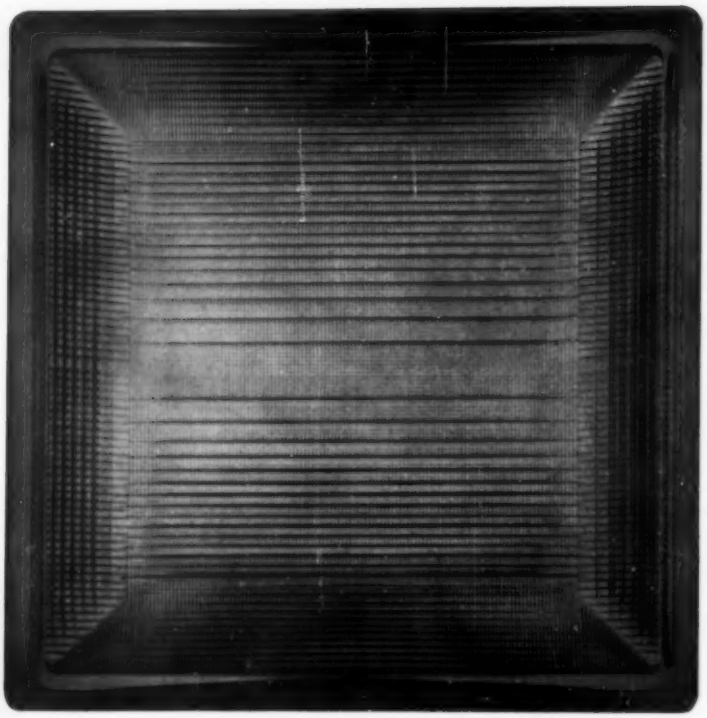

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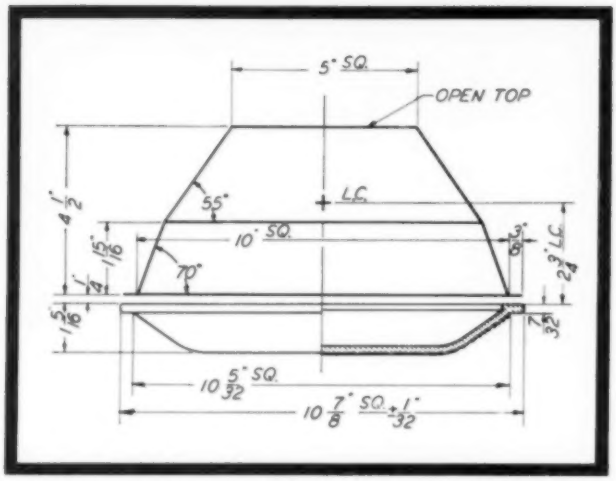

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(Continued from page 35A)

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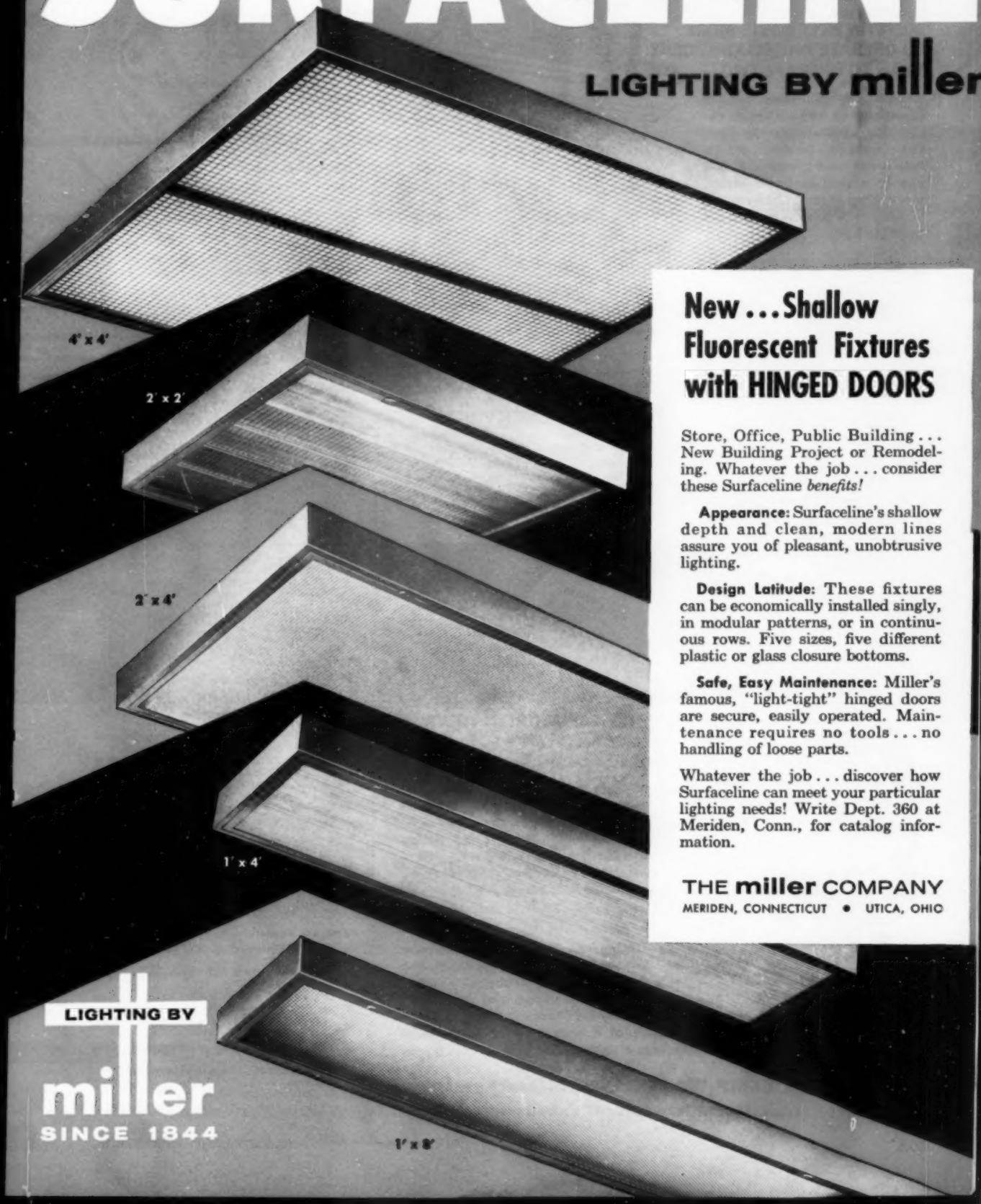
Retired membership privileges, available to qualified members (30 years in the Society and 65 years of age), include reduced annual dues ($5.00) and the continued receipt of all mailings. Classifications are Member, Retired; Fellow, Retired; Associate Member, Retired. Those interested should write to the General Secretary at Headquarters.

SURFACELINE

LIGHTING BY miller



New . . . Shallow Fluorescent Fixtures with HINGED DOORS

Store, Office, Public Building . . . New Building Project or Remodeling. Whatever the job . . . consider these Surfaceline *benefits!*

Appearance: Surfaceline's shallow depth and clean, modern lines assure you of pleasant, unobtrusive lighting.

Design Latitude: These fixtures can be economically installed singly, in modular patterns, or in continuous rows. Five sizes, five different plastic or glass closure bottoms.

Safe, Easy Maintenance: Miller's famous, "light-tight" hinged doors are secure, easily operated. Maintenance requires no tools . . . no handling of loose parts.

Whatever the job . . . discover how Surfaceline can meet your particular lighting needs! Write Dept. 360 at Meriden, Conn., for catalog information.

THE miller COMPANY
MERIDEN, CONNECTICUT • UTICA, OHIO

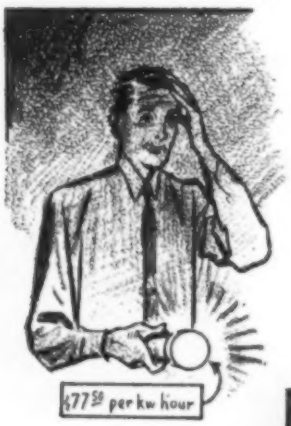
LIGHTING BY
miller
SINCE 1844

Facts of Light!

CHAMPION Lamps

SOMETIMES IT COSTS MORE TO OPERATE ONE FLUORESCENT THAN TO OPERATE TWO

When only one fluorescent lamp is operating on a lead-lag ballast designed to handle two lamps, more line current can be drawn than if both lamps were operating. This is due to a shift in power factor. Moral: keep all lamps operating — you can draw less current and get twice the light.



IT COSTS $77.50 per KW hour to RUN A FLASHLIGHT

When a lamp is run on a flashlight battery the power cost is in the vicinity of $77.50 per KW hour. The power cost to operate lamps from residential electric supply is only 2.66 cents per KW hour.

A LITTLE VARIATION IN VOLTAGE CAN MEAN A LOT IN THE LIFE OF A LAMP

Incandescent lamps are designed to yield maximum lighting economy when used on circuits where the voltage is the same as that printed on the bulb. When the circuit voltage is 5 volts above the bulb rating lamp life can be cut in half. A variation of 5 volts below rating can double lamp life.

YOUR NEW CHAMPION LAMP HAS ALREADY BEEN LIGHTED AT LEAST 7 TIMES

Every Champion lamp is lighted a minimum of 7 times before it is packaged. Checks like this are typical of the strict quality control maintained at Champion and one of the reasons why the Champion Diamond on the outside of a lamp means a dependable source of light on the inside.

CHAMPION LAMP WORKS, Lynn, Massachusetts

CHAMPION INCANDESCENT-FLUORESCENT • *YOUR BEST BUY IN LAMPS*

(Continued from page 26A)

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Kraft, Leonard, Rosco Laboratories, Inc., Brooklyn, N. Y.
Miller, Stanford, Rosco Laboratories, Inc., Brooklyn, N. Y.

(Continued on page 42A)

Here's the latest idea in continuous lighted ceilings...

It's in the new Union Carbide building on New York's Park Avenue. The light-diffusing panels of BAKELITE Brand rigid vinyl sheets are supported by stainless steel runners that are part of the ventilating and cooling systems and also serve to anchor the movable wall partitions.

Today, you can get BAKELITE rigid vinyl sheets that are practically immune to the cracking that raises the cost of installing and maintaining continuous lighted ceilings. That's because these sheets are formulated and fabricated especially for light diffusion. They are expected to last for years without yellowing in standard installations.

They're self-extinguishing, but the installation can be designed so they'll soften and fall out before the sprinkler operating temperature. Installing them with baffles or laminating with special sound-deadening material gives them good acoustical properties. Costs can be cut because much thinner sheets can be used than for other types of diffusers.

There are many other things to look for in BAKELITE rigid sheets for continuous lighted and luminous ceilings. If you're not getting them all, write for facts, literature and a list of suppliers, Dept. CN-81K, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Ltd., Toronto, Ont.

UNION CARBIDE

"Bakelite" is a registered trade-mark of Union Carbide Corporation.

"SEEMORE" SAYS:
A COMPLETE FAMILY OF GUTH BRASCOLITE
PIN-HOLES
for any size lamp—from 75 to 1,000 watts
A complete line of versatile, high-quality recessed fixtures for "pinpoint" light control in auditoriums, stores, churches, etc. They provide high-intensity lighting from a nearly invisible source—all you see is the "pin-hole!"
U.L. Listed.
Every model is designed for easy installation, relamping and cleaning
SHOVEL YOUR LIGHT TO WHERE IT'S NEEDED
300 to 1,000 watt models available with "light shovels"... for directing light to walls or other specific areas.
WRITE FOR "PIN-HOLE DATA SHEETS" TODAY
Guth brascolite
THE EDWIN F. GUTH CO.
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(Continued from page 40A)

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(Continued on page 44A)

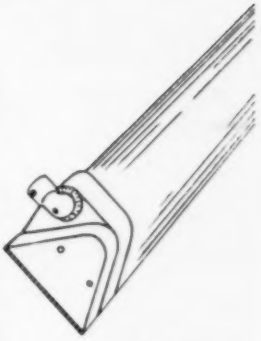
Revere Outdoor Lighting Report

Revere ELECTRIC MFG. CO.

Lighting a truck loading dock

The Problem: To light the entrance of a trucking depot loading dock. Light level must be high enough for safety and for precise parking of large trucks.

The Answer: Revere Fluoresign Outdoor Luminaires were installed over the doorways insuring safety, security and providing ideal visibility. This made nighttime parking as safe, fast and easy as daylight parking. The depot's eight entrances and its entranceway were lighted at the level of 12 to 15 footcandles with the all-weather fluorescent luminaires. Adjusting Fluoresign for best light spread can be done with lamps in and burning.

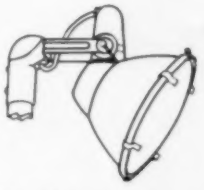


No. 8650 Series
Fluoresign Outdoor Luminaire

Lighting a tennis court

The Problem: To make night tennis play possible by providing the high level of uniform light required for good visibility in this high-speed game.

The Answer: Revere 4200 series floodlights mounted on Revere hinged poles were installed to provide the high level of light desired. Poles down the center of the courts have four floodlights, directed in pairs toward adjacent courts. Poles around perimeter of the court area have two floodlights each. Mounting height for all floodlights is 30 ft. Installation gives average maintained illumination of 13 footcandles.

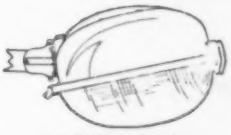


No. 4200 Series Floodlight

Lighting a shopping center parking lot

The Problem: To illuminate a large parking lot for safety in driving and parking, ease in locating parked cars, and to make the shopping center look more inviting.

The Answer: Revere Endoval Mercury Luminaires were used to illuminate driving lanes, and Revere No. 3350 Series Floodlights were installed to provide high-level illumination of 1.1 average maintained footcandles for the parking areas. The equipment is mounted on Revere hinged poles, using Revere brackets and arms. The hinged poles permit easier, safer, and more economical maintenance and relamping from the ground. Pole spacing is 150 ft.



No. 2282 Endoval
Mercury Luminaire

No. 3350 Series Floodlight

Write for Revere's complete catalog of outdoor lighting equipment

Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
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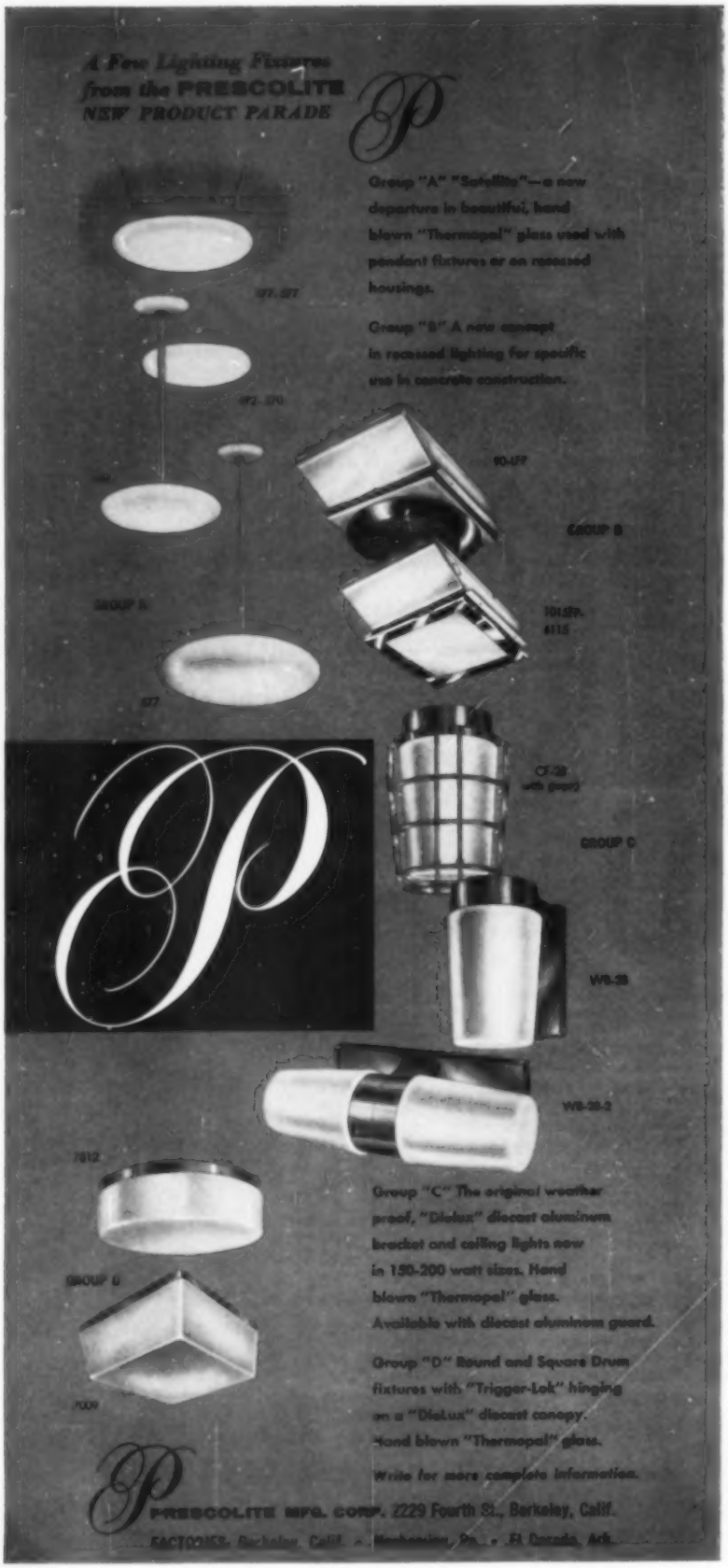
A Few Lighting Fixtures from the PRESCOLITE NEW PRODUCT PARADE
Group "A" "Satellite"—a new departure in beautiful, hand blown "Thermopal" glass used with pendant fixtures or on recessed housings.
Group "B" A new concept in recessed lighting for specific use in concrete construction.
Group "C" The original weather proof, "DieLux" diecast aluminum bracket and ceiling lights now in 150-200 watt sizes. Hand blown "Thermopal" glass. Available with diecast aluminum guard.
Group "D" Round and Square Drum fixtures with "Trigger-Lok" hinging on a "DieLux" diecast canopy. Hand blown "Thermopal" glass.
Write for more complete information.
PRESCOLITE MFG. CORP. 2229 Fourth St., Berkeley, Calif.
FACTORIES: Berkeley, Calif. • Manhasset, N. Y. • El Dorado, Ark.

(*Continued from page* 42A)

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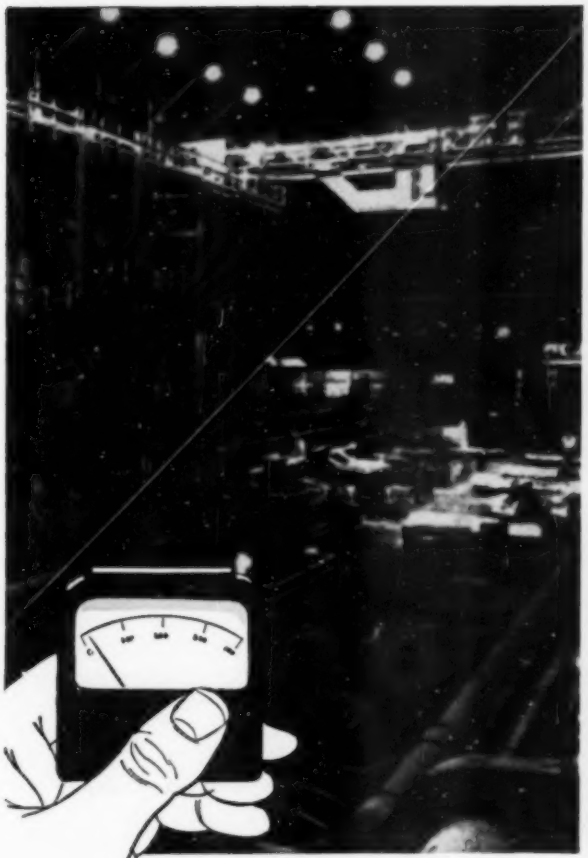
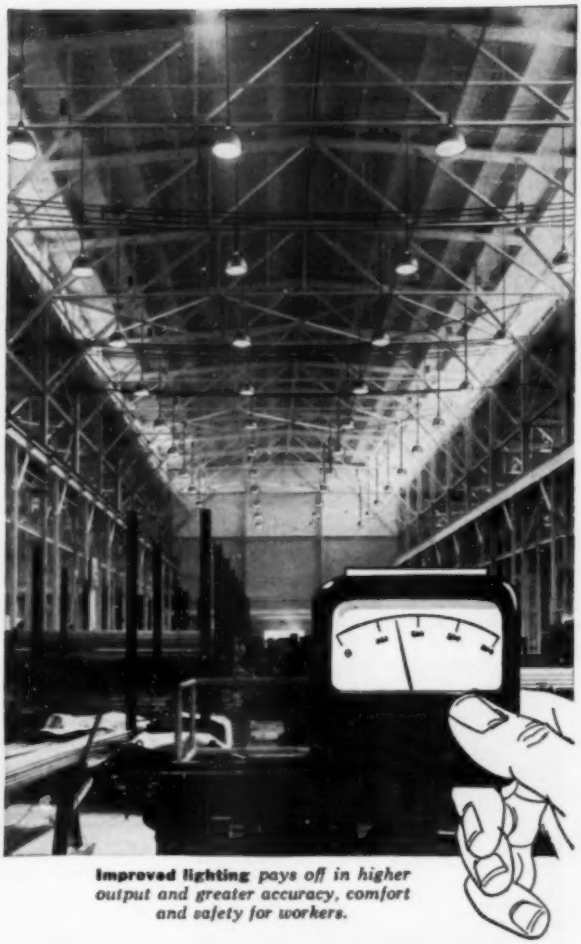
Wilson, W. D., H. Simmons E. E., Inc., Long Beach, Calif.

(*Continued on page* 46A)



Dull, dreary lighting *cuts down worker efficiency, causes eye strain, makes many work tasks hazardous.*



Improved lighting *pays off in higher output and greater accuracy, comfort and safety for workers.*

Abolite lifts the lighting level

In the picture on the right, those Abolite fixtures provide a high level of comfortable, glareless light throughout this high bay building. 18% of the light is directed upward through Abolite's open top, washes out the deep shadows, gives lamps a soft background. 35° shielding of lamp practically eliminates glare.

Open-top design also gives Abolite high bay units a self-cleaning action. Air circulates through the fixture, sweeps reflecting surface clean.

Choose from several Abolite uplight units for high bay lighting: 18" and 24" Alzak aluminum fixtures for 400 and 1000 watt mercury lamps; and 14" and 18" fixtures for 300-500 watt incandescent lamps (ideal for gymnasium lighting). For full information, write *Abolite Lighting Division, The Jones Metal Products Company, West Lafayette, Ohio.*

Abolite Cat. No. HMFAU-2400 Alzak aluminum uplight fixtures with 400 watt white reflector Mercury lamps.

eye-fi RE/LIGHTING

ABOLITE Lighting

THE JONES METAL PRODUCTS COMPANY

West Lafayette, Ohio

PUT YOURSELF
IN A *BETTER LIGHT*
WITH metco Lighting

Power
LITE
FLOATING
CEILING

Economical . . . Compact
HIGH LEVEL
Comfortable Illumination

Power-LITE is a pendant type fixture (C.I.E. general diffuse classification) modular in design. It provides high intensity, glare-free, direct-indirect illumination in a large area. Utilizing new high lumen output 15,000 MA lamps, it provides up to 200 to 450 foot-candles of illumination at working levels, comfortably shielded by 45°-45° aluminum or plastic louvers. Power-LITE is a completely satisfactory alternative to suspended ceiling construction that minimizes lighting contrasts by distributing its light on ceiling and walls as well as down on the working area.

Write today for full details and catalog sheet.

SOLD ONLY THROUGH QUALIFIED ELECTRICAL DISTRIBUTORS

METALCRAFT
PRODUCTS CO., INC.
6225 State Road, Phila. 35, Pa.

(*Continued from page 44A*)

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4 bright ideas...

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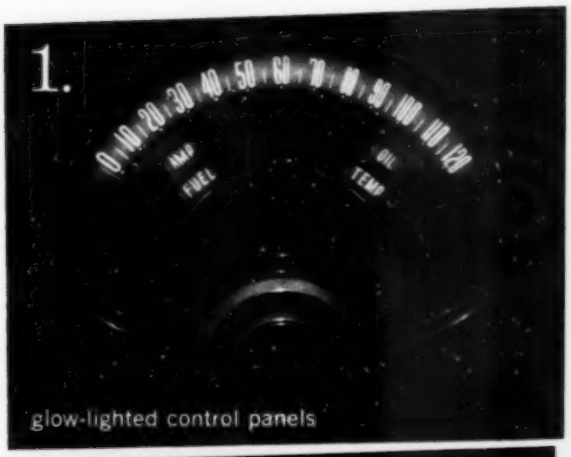

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The Greatest Dimmers on Earth!

The Kliegl manufactured Stage Manager's "Nerve Center" contains 6 SCR Dimmers (24,000 watt total capacity) for lighting control. In addition, it has controls for curtains and hoists . . . intercommunications system . . . power panel for feeding back-stage electrical equipment . . . in a few words *complete electronic control in a compact portable console.*

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The #210 SNAPEE Grid Hanger snaps onto "T" bar, slides into desired position and locks securely at right spot. Mount fixture in position, fasten wing nut, and the job's done.

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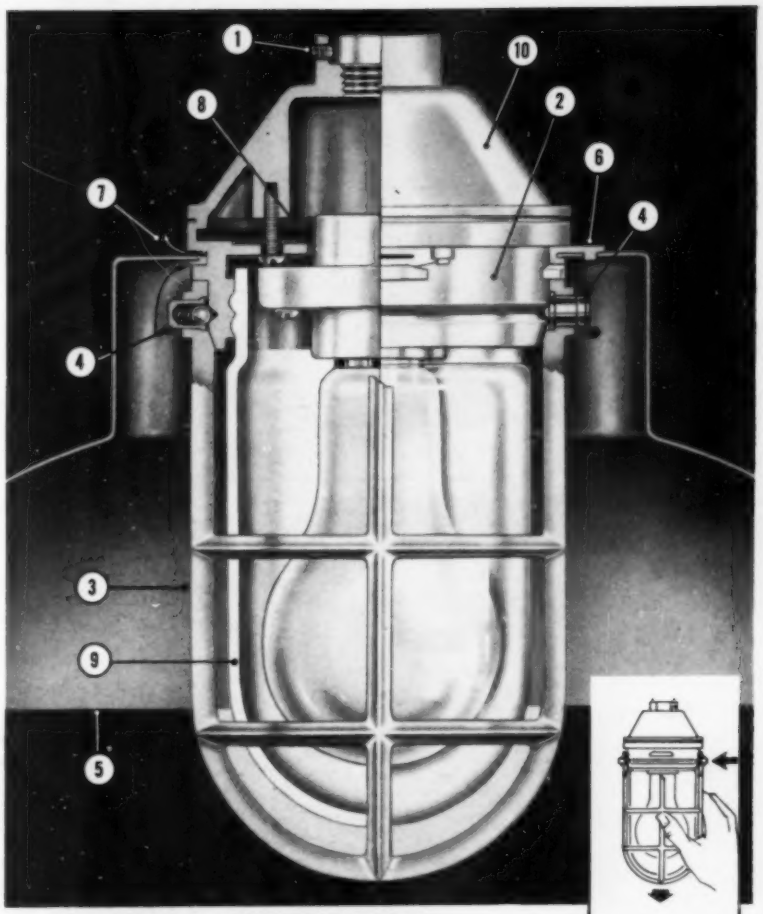

Guards removable without tools.

NEW STEBER
ALUMINUM VAPORTITE INDUSTRIAL LIGHTING FIXTURES

1. Pendent mounting, die-cast aluminum with lock screw.
2. Universal Fixture Body, die-cast aluminum—takes pendent, ceiling and wall bracket adaptors.
3. Protective guard, die-cast aluminum.
4. Stainless Steel Ball Detents—permit attachment and removal of guard without aid of tools.
5. White Porcelain Enameled Reflector—Standard Dome, Shallow, Deep Bowl or 30° Angle.
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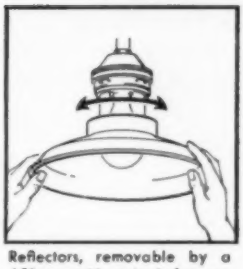
7. Reflector Ventilating gaps provide chimney action cooling and cleaning.
8. Gasketed construction isolates wiring compartment.
9. Heat-resistant glass globe, clear or choice of four colors.
10. All aluminum components coated with graytone baked ULTRANAMEL to protect against chemical fumes, caustic, etc.



Reflectors, removable by a 45° turn without tools for convenient cleaning.

Specification Bulletin No. 1099-60 available on request.

New, Complete Steber line is years ahead in design, engineering and construction. Steber units *have* the features you want. Their functional design gives you the complete easy adaptability you need. Steber Fixtures are U/L and CSA approved and meet Navy, Corps of Engineers and General Service Administration specifications.

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Sola transformer No. 77020 maintains rated lumen output of H15 lamp in Holophane fixture within ±1% even if primary voltage should vary over 200 to 260v range.

Newest line of indoor Sola constant-wattage mercury-lamp transformers features light weight, improved case construction; starts mercury lamps down to 20° below zero.

Sola-ballasted mercury lamps specified for new generating station

Here are five performance benefits that make Sola constant-wattage transformers pay off in modern mercury lighting installations: Light output is constant within ±1% with line voltage changes as great at ±13%. Line-current starting surge is limited to normal operating value—eliminates need for heavier wiring, time-delay relays. The constant-wattage circuit limits primary current under abnormal conditions—lamp failure or secondary short circuit will not overheat the transformer. Stable operating conditions insure rated lamp life. Line voltage must dip 30% below nominal before lamps extinguish.

The utility's engineers and consultants recognized these benefits and specified constant-wattage transformers. Consult your Sola lighting representative for further information, or write for Bulletin MV-396.

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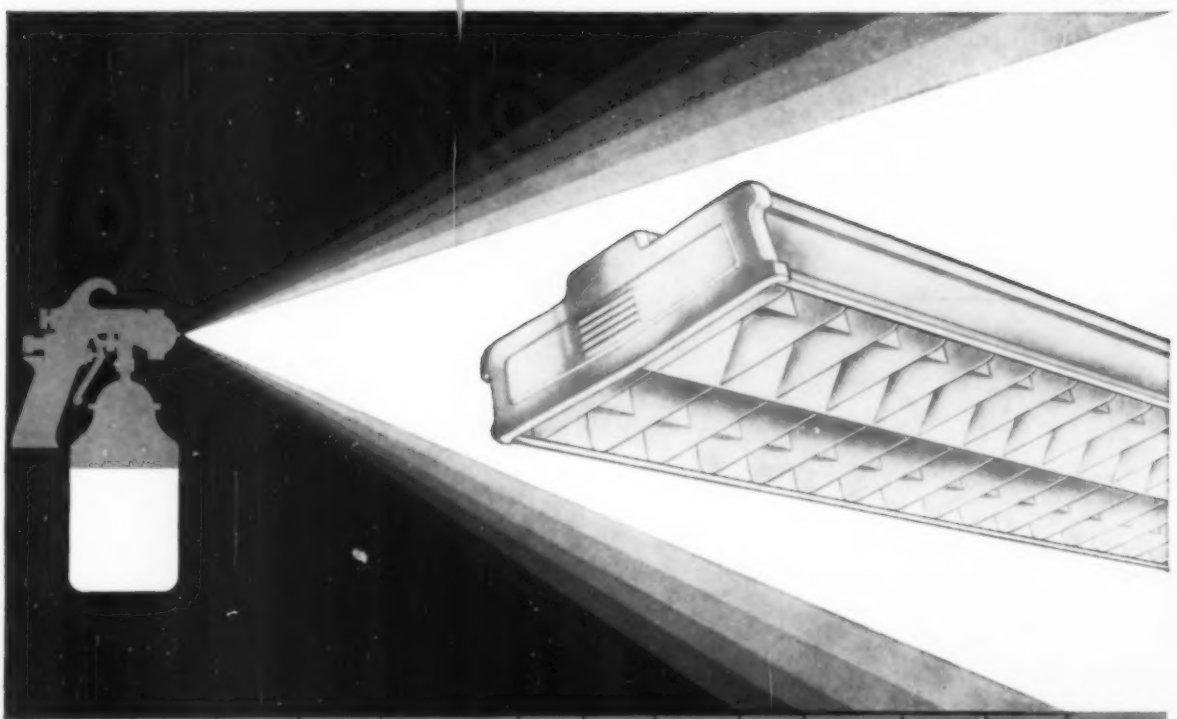

	Adhesion To Metal	Humidity Resist.	Salt Spray Resist.	Fume Resist.		Stain Resist.	Grease Resist.	Hardness	Mar Resist.	Evaporated Adhesion	Baking Color Stability	Heat Resist. (1)	Color Retens. Exposed to Ultraviolet
				Grease	Tobacco Smoke								
GOOD QUALITY FINISHES	8.0	8.5	8.5	7.5	6.5	5.0	7.0	8.0	8.5	8.5	7.5	8.0	6.0
NEW GUTH LUCITE* FINISH	9.5	10.0	9.5	8.5	9.0	9.0	10.0	22.0	9.5	10.0	8.5	9.0	9.0
PERCENT BETTER	18.75%	17.65%	11.76%	13.33%	38.46%	80.00%	42.86%	175.00%	11.76%	17.65%	13.33%	80.00%	50.00%

(1) 30 min. at 400° F. * ® DuPont

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